

EXHIBIT A



US005684722A

United States Patent [19]

Thorner et al.

[11] **Patent Number:** 5,684,722[45] **Date of Patent:** Nov. 4, 1997

[54] **APPARATUS AND METHOD FOR
GENERATING A CONTROL SIGNAL FOR A
TACTILE SENSATION GENERATOR**

[76] **Inventors:** Craig Thorner, 16 Nantucket Ct.,
Howell, N.J. 07731; Thomas K. Glass,
277 Frank Applegate Rd., Jackson, N.J.
08527

[21] **Appl. No.:** 309,763

[22] **Filed:** Sep. 21, 1994

[51] **Int. Cl.⁶** G06F 17/00

[52] **U.S. Cl.** 364/578

[58] **Field of Search** 364/578, 514,
364/DIG. 1, DIG. 2; 360/14.2; 340/712;
345/156; 84/645, 610, 464 R, 601, 602,
609, 611, 634, 635, 641, 642, DIG. 1, DIG. 2,
DIG. 29; 395/152, 153, 154, 155

[56] **References Cited****U.S. PATENT DOCUMENTS**

1,738,289	12/1929	Fletcher	463/30
4,081,829	3/1978	Brown	358/82
4,257,062	3/1981	Meredith	358/81
4,310,315	1/1982	Frank et al.	434/114
4,581,491	4/1986	Boothroyd	434/114

4,771,344	9/1988	Fallacaro et al.	358/335
4,988,981	1/1991	Zimmerman et al.	340/709
5,307,456	4/1994	MacKay	395/154
5,374,924	12/1994	McKiel, Jr.	463/30
5,388,992	2/1995	Franklin et al.	434/114
5,513,129	4/1996	Bolas et al.	364/578
5,513,130	4/1996	Redmond	364/578

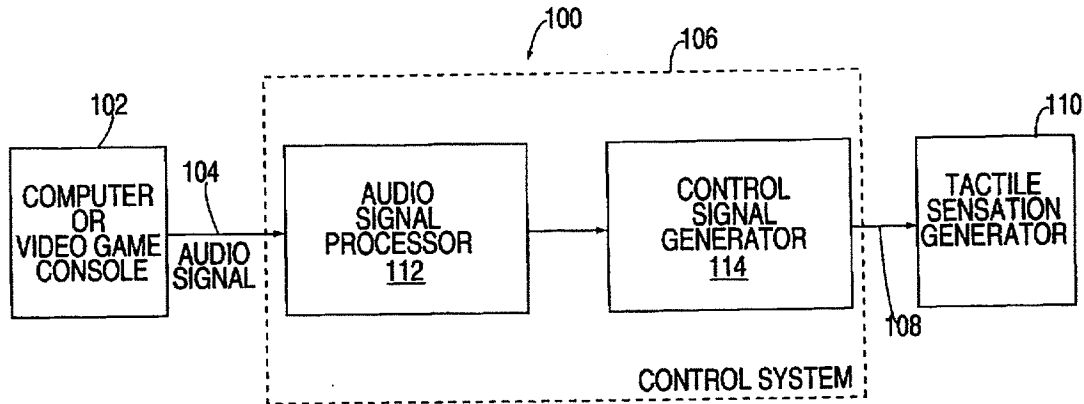
Primary Examiner—Ellis B. Ramirez

Attorney, Agent, or Firm—Thomason & Moser

[57] **ABSTRACT**

A control system that is responsive to an audio signal generated by an audio source such as a computer, video game console, stereo system and the like. The control system converts the audio signal into a control signal for a tactile sensation generator such as a vibrating cushion, vibrating seat pad, and the like. The control system contains an audio signal processor and a control signal generator. The audio signal processor produces a processed signal indicative of the amplitude, frequency, and rate of change of the audio signal. From the processed signal, a control signal generator produces a control signal for a tactile sensation generator. The control signal causes the tactile sensation generator to produce a tactile sensation corresponding to the present scene being displayed, for example, on a monitor of a computer executing a computer game.

27 Claims, 4 Drawing Sheets

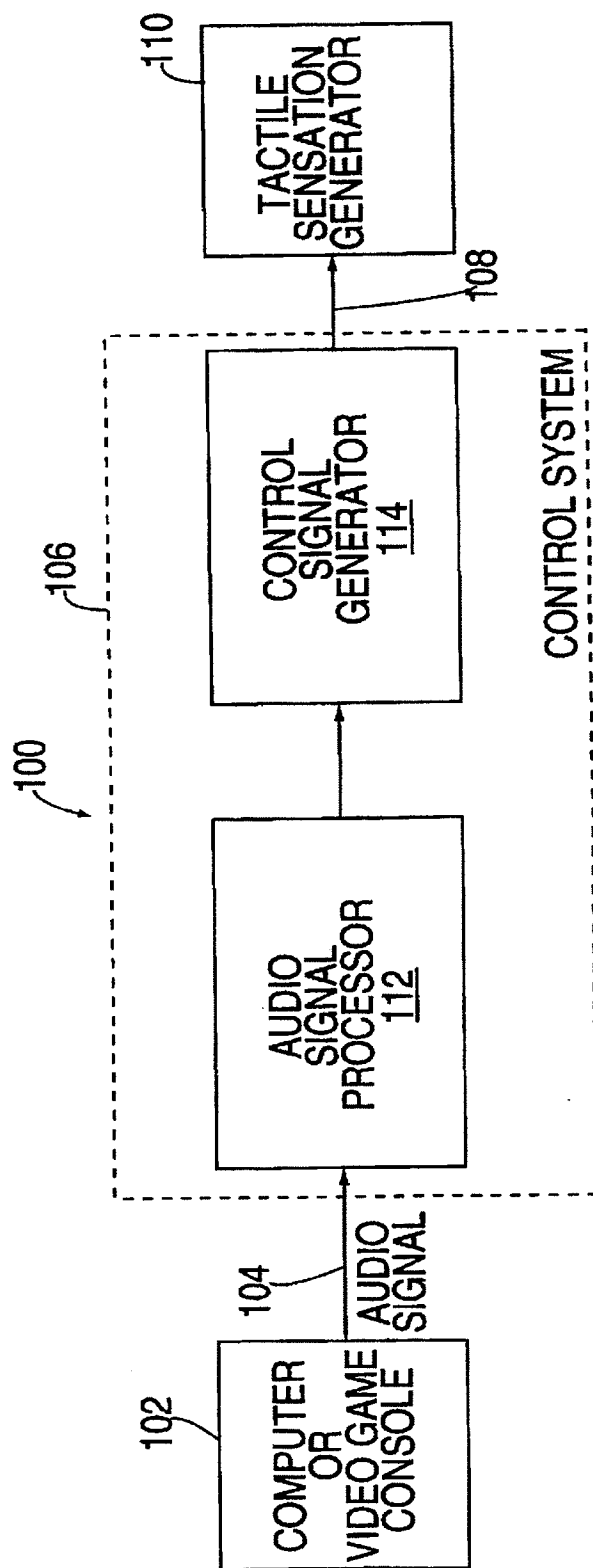


U.S. Patent

Nov. 4, 1997

Sheet 1 of 4

5,684,722



U.S. Patent

Nov. 4, 1997

Sheet 2 of 4

5,684,722

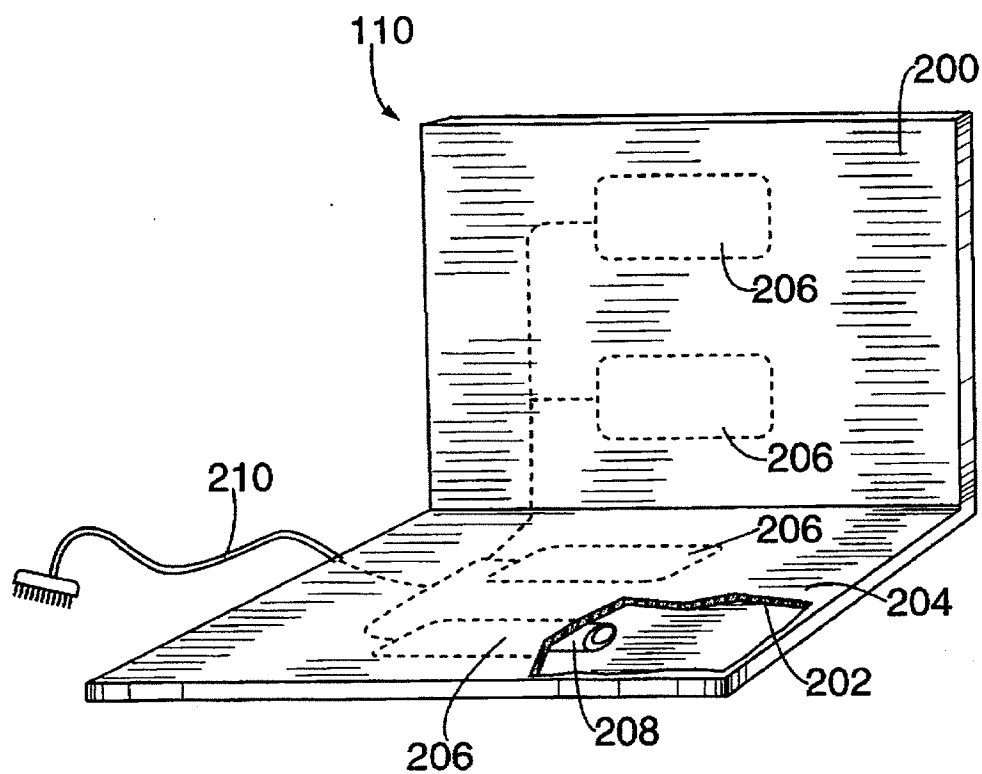


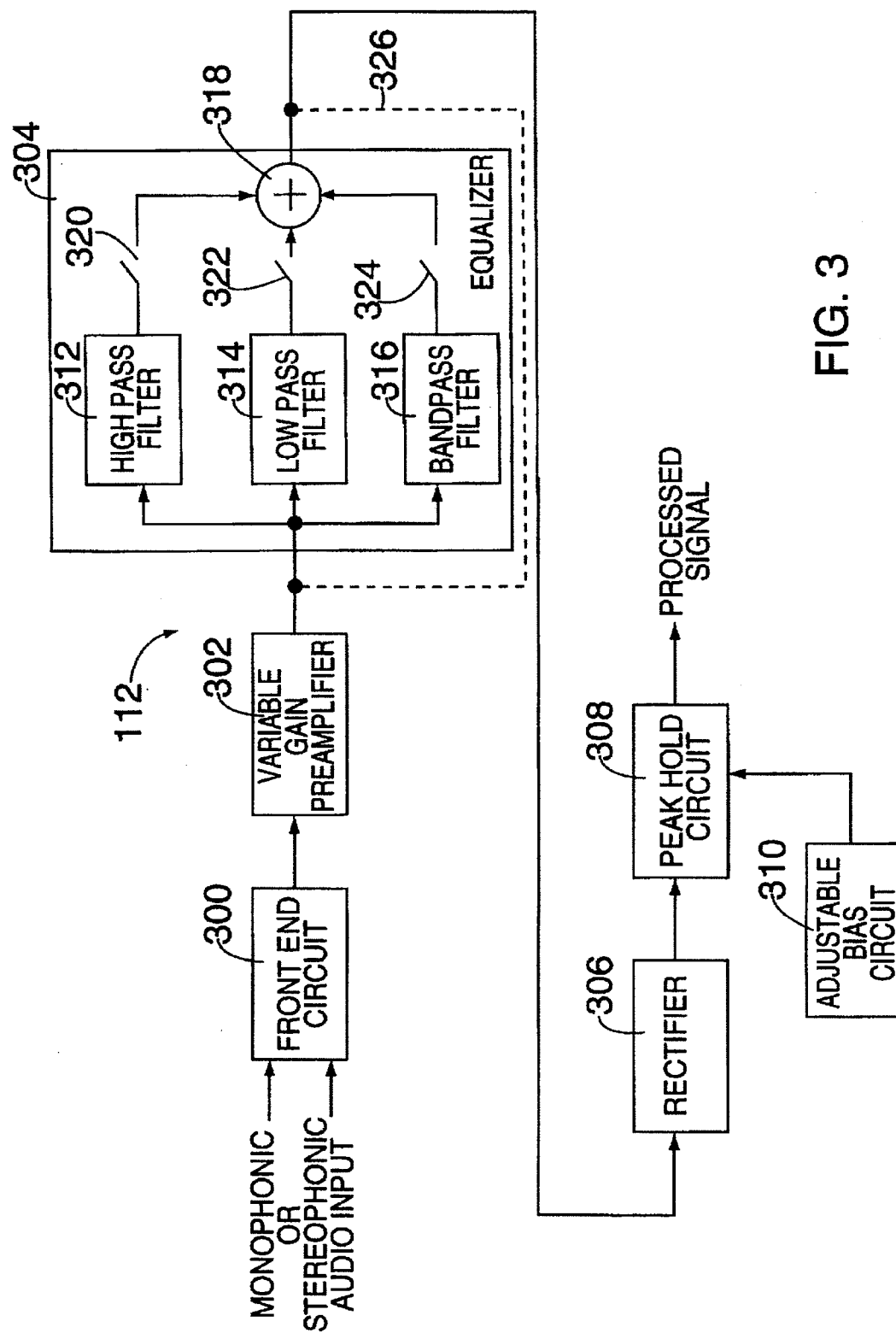
FIG. 2

U.S. Patent

Nov. 4, 1997

Sheet 3 of 4

5,684,722



U.S. Patent

Nov. 4, 1997

Sheet 4 of 4

5,684,722

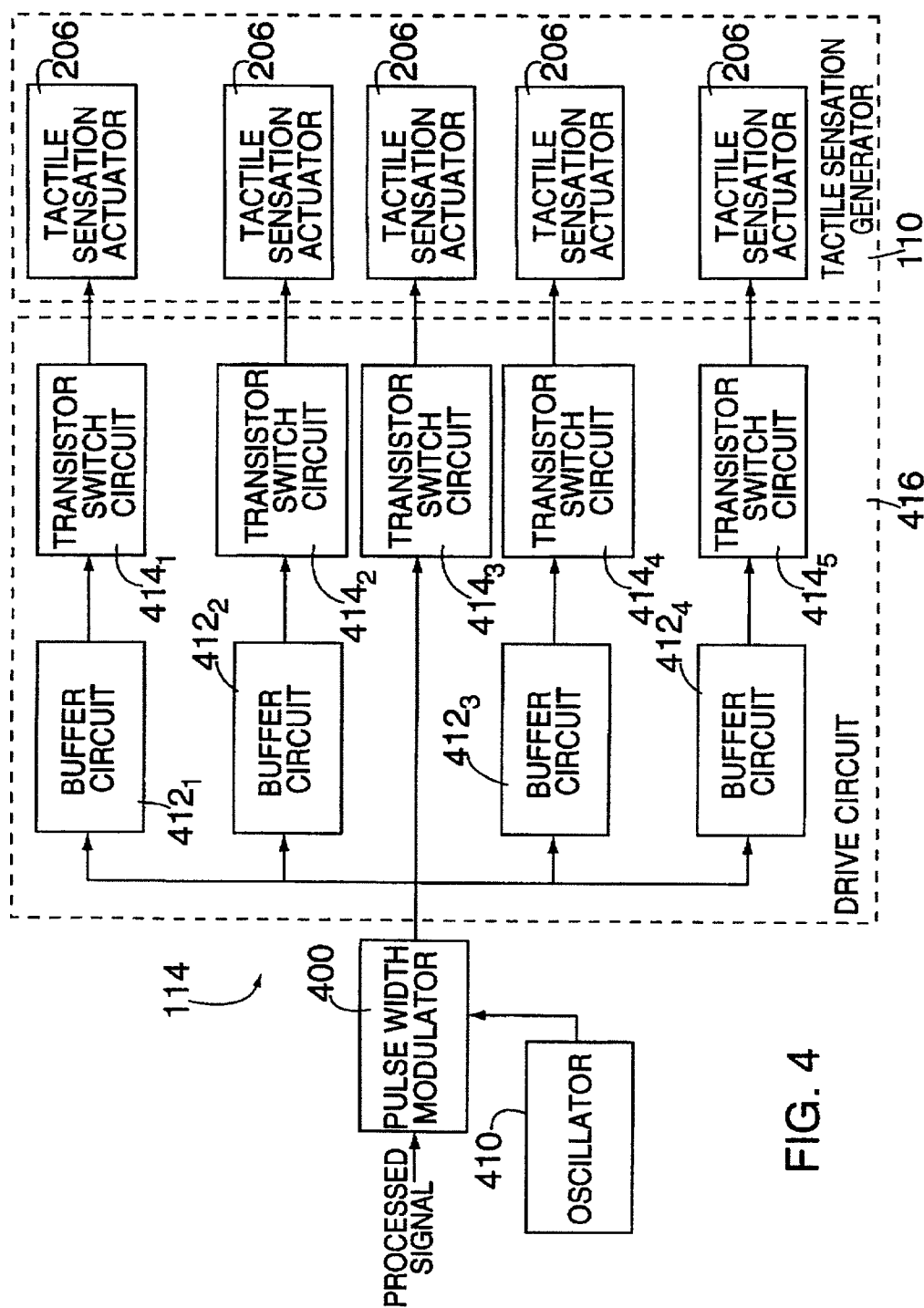


FIG. 4

5,684,722

1

APPARATUS AND METHOD FOR GENERATING A CONTROL SIGNAL FOR A TACTILE SENSATION GENERATOR

BACKGROUND OF THE DISCLOSURE

1. Field of the Invention

The invention relates to virtual reality computer systems and, more particularly, to circuitry for converting an audio signal into a control signal for a tactile sensation generator within a virtual reality computer system.

2. Description of the Prior Art

Video games are typically executed by microprocessors within dedicated game consoles or computers such that a player interactively manipulates a video game scene as displayed on a video monitor or television using a keyboard, mouse, joystick, or some other command input device. In addition to the video output, most game apparatus also produces an audio output that corresponds to the scene presently displayed on the monitor. In this manner, the game apparatus exposes a player is exposed to both auditory and visual sensation.

Although today's audio-visual game experience is exciting, the excitement is limited by the game's inability to produce any form of tactile sensation corresponding to the scene being displayed. Generally, tactile sensation, such as vibration, fist and bullet strikes and the like, have not been simulated with any great success. In one available tactile sensation generator, a modified speaker is positioned below a player's seat such that low frequencies in the sound applied to the modified speaker will vibrate the seat. In such a system, the sound volume must be very loud to achieve the sensation of vibration.

Therefore, a need exists in the art for circuitry that processes an audio signal produced by a video game program or other audio source and generates, in response to the audio signal, control signals to activate a tactile sensation generator.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of the prior art by providing apparatus, and a concomitant method, of generating, from an audio signal, a control signal for a tactile sensation generator. Specifically, the invention is a control system that is responsive to an audio signal generated by an audio source such as a computer, video game console, stereo system, microphone and the like. The control system converts the audio signal into a control signal for a tactile sensation generator such as a vibrating cushion, vibrating seat pad, and the like. The control system contains an audio signal processor and a control signal generator. The audio signal processor produces a processed signal indicative of the amplitude, frequency, and rate of change of the audio signal. From the processed signal, a control signal generator produces a control signal for a tactile sensation generator. The control signal causes the tactile sensation generator to produce a tactile sensation corresponding to the present scene being displayed, for example, on a monitor of a computer executing a computer game program.

BRIEF DESCRIPTION OF THE DRAWINGS

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 depicts a high level block diagram of a tactile sensation generation system;

2

FIG. 2 schematically depicts an illustrative tactile sensation generator;

FIG. 3 depicts a detailed block diagram of the audio signal processor of FIG. 1; and

FIG. 4 depicts a detailed block diagram of the control signal generator of FIG. 1.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

FIG. 1 depicts a high level block diagram of a tactile sensation generation system 100 containing a computer system or video game console 102, a tactile sensation generator 110 and a control system 106 for the tactile sensation generator 110. The control system 106 further contains an audio signal processor 112 and a control signal generator 114. The home computer 102 may, of course, be replaced with any device that produces an audio signal such as a video game console, stereo system, television receiver, microphone, and the like. However, for simplicity, throughout this disclosure, it is assumed that the audio source is a conventional home computer executing a video game program. As such, the control system 106 converts the audio signals conventionally generated by the video game into control signals for the tactile sensation generator.

More specifically, the computer 102 has its audio output port, e.g., an earphone jack, connected, via line 104, to audio signal processor 112 within the control system 106. In general, the signal processor analyzes the frequency, amplitude, and rate of change of the audio signal produced by the currently executing video game. From the analysis of the audio signal, the audio signal processor 112 produces a processed signal. The processed signal forms an input to the control signal generator 114 which produces a control signal, on line 108, for the tactile sensation generator 110.

The tactile sensation generator can be one or more devices (actuators) capable of simulating vibration, punches, bullet strikes and the like in accordance with specific control signals. Consequently, while using the inventive apparatus, a player experiences a virtual reality while interacting with the video game. To provide a full understanding of the invention, a detailed example of a tactile sensation generator is provided below.

FIG. 2 depicts one example of a tactile sensation generator 110 capable of being controlled by the control system 106. Specifically, the tactile sensation generator contains a seat pad 200 having localized vibration producing actuators 206 distributed within the pad. The seat pad 200 is a foam cushion 202 enclosed in a cloth cover layer 204. Beneath the cover layer 204 are electric motors having offset weights mounted to their shafts. One such motor 208 is depicted in FIG. 2. When activated by control signals applied via wires 210, the shafts of the motors rotate and the offset weights cause the motors to vibrate. The depicted seat has four such vibrating motors. A seat pad of this type is available as model 905 from JB Research of Los Angeles, Calif. Although tactile sensation is generated in this example by vibrating electric motors, those skilled in the art will realize that any type of vibrating actuator may be used in lieu of motors including buzzers, solenoids, piezo-electric actuators, and the like. Also, any number of actuators can be used, i.e., one or more actuators. Furthermore, the tactile sensation actuators do not have to be vibratory. It is foreseeable that other forms of generators such as solenoids could be used to poke and prod a player with a single strike when a bullet or fist impact is to be simulated.

5,684,722

3

Using the seat pad described above, a video game such as an auto racing game produces simulated vibration as a player's video game car accelerates, e.g., increased vibration with engine revs (higher pitched sound). The amplitude and frequency of the vibration is changed as the video car changes speed. Also, impacts with obstacles that are evidenced by low frequency, high amplitude audio signals result in forceful, high-frequency vibrations throughout the seat pad. Consequently, while playing the video game, a player receives a tactile sensation of actually sitting in a race car. To enhance the virtual reality effect, vibrating wrist and/or ankle tactile sensation generators can be applied to the player in addition to the seat pad. In accordance with the teachings of the present invention, the control system 106 produces control signals for the vibration actuators 206.

FIG. 3 depicts a detailed block diagram of the audio signal processor 112. In general, the input to processor 112 is an audio signal from an audio source, any audio source. The signal may be either stereophonic or monophonic. The processor 112 responds to the pitch (frequency), volume (amplitude) and rate of change of the audio signal by producing a processed signal indicative of these characteristics of the input audio signal.

Specifically, the audio signal processor 112 contains a front end circuit 300, a preamplifier 302, an equalizer 304, a rectifier 306, a peak hold circuit 308, and an adjustable bias circuit 310. These major components are more or less connected in series.

More specifically, the front end circuit 300 contains a mixer for combining both channels of a stereophonic audio signal to form a composite audio signal, a high pass filter for limiting noise that is below of the audio band, e.g., lower than 20 Hz, and a diode signal limiter for limiting (clipping) the amplitude of the input signal to protect the audio signal processor from being damaged by overly powerful input audio signals. Circuitry 300 is connected to a variable gain preamplifier 302.

The variable gain preamplifier 302 establishes the dynamic range of the entire audio signal processor 112. For instance, if the gain of the preamplifier is set to high, any loud (high amplitude) signals would saturate the processor and, as such, not create the desired tactile sensation. On the other hand, if the preamplifier gain is set too low, low amplitude audio signals would not generate any tactile sensation and only high amplitude signals would cause a tactile response. Consequently, a player must adjust the gain of the preamplifier to conform to audio signal levels generated by the game currently being played. In other words, the specific gain setting depends upon the dynamic range of input audio signal and the player's tactile sensation preferences. Illustratively, the voltage gain of the preamplifier is variable from no gain to a 1000 times. In some applications where the audio signal has a low amplitude, additional fixed gain amplification may be necessary before and/or after the variable gain preamplifier.

Once amplified, the audio signal forms an input to the equalizer 304. The equalizer contains three parallel connected filters: a high pass filter 312, a low pass filter 314, and an bandpass filter 316. The high pass filter has an illustrative passband of 2 kHz to 13 kHz, the low pass filter has an illustrative passband of 28 Hz to 350 Hz, and the bandpass filter has a passband of 230 Hz to 10.3 kHz. The three paths each form an input to a summing amplifier 318. Additionally, each of the three paths has a switch (switches 320, 322, and 324) to select one or more of the paths as an input to the summing amplifier 318. As such, depending on

4

which of the signal paths are connected to the summing amplifier, the equalizer can selectively amplify or attenuate low frequencies, high frequencies or both. As such, a game player can adjust the frequency content of the audio that is used to generate tactile sensation generator control signals and, consequently, tailor the tactile sensation to the game being executed.

Nonetheless, the equalizer 304 is an optional circuit for the invention. The equalizer permits optimizing the tactile sensation to a audio source, e.g., the equalizer enables a video game player to exclude the background music of the game from the audio signal that produces a tactile sensation. Therefore, if such additional flexibility is not desired, the equalizer can be deleted.

The rectifier 306 is provided to produce a positive signal from the bi-polar filtered audio signal. The peak hold circuit 308 responds quickly to the peak amplitude of the rectified signal, but slowly decays from that peak amplitude. Specifically, the peak hold circuit contains a parallel combination of a capacitor and a resistor. The capacitor charges as the rectified audio signal is applied thereacross. The resistor has a very large resistance, e.g., 10M Ω , such that the capacitor (0.022 μ F) discharges slowly through the resistance. As a result, the capacitor temporarily holds the peak amplitude of the rectified audio. The voltage level on the capacitor forms an input to a high impedance voltage amplifier. This implementation of the peak circuit samples both the frequency and amplitude of the rectified audio signal, i.e., when either the frequency or amplitude of the input signal change, the output signal will change to some degree. As such, the output of the peak hold circuit contains information pertaining to the frequency and amplitude of the rectified signal.

The specific time constant of this RC circuit is defined by the response time of the actuators used in the tactile sensation generator. For example, the response of electric motors is rather slow; therefore, the resonant frequency of the RC circuit would be approximately 90 Hz. In contrast, if the actuators in the tactile sensation generator are piezo-electric actuators; then, the resonant frequency of the RC circuit would be on the order of a thousand hertz or more.

Also, a DC bias voltage, generated by adjustable bias circuit 310, is added to the peak held signal such that the amplifier output signal is a composite (sum) of the peak held signal and the DC bias value. The bias value is a player adjustable offset. The utility of this DC bias is discussed below. The biased and amplified peak held signal is hereinafter referred to as a processed signal.

FIG. 4 depicts a detailed block diagram of the control signal generator 114. Specifically, the control signal generator contains a pulse width modulator 400, an oscillator 410, and drive circuit 416 for the tactile sensation generator 110. The processed signal forms an input to the pulse width modulator 400, e.g., a conventional 555 timer. Those skilled in the art will realize from this disclosure that other forms of modulation such as frequency modulation are also useful in lieu of pulse width modulation.

The pulse width modulator generates a pulse having a width that corresponds to the amplitude of the input signal to the pulse width modulator. As such, if a constant DC voltage level (e.g., the DC bias discussed above) forms an input to the pulse width modulator, the modulator will generate an output pulse having a pulse width indicative of the amplitude of that DC signal. When an AC signal forms the input to the modulator (e.g., the processed signal), each output pulse from the modulator has a duration that is

5,684,722

5

indicative of the instantaneous amplitude of the AC signal sampled at the clock rate. As such, for each clock pulse, the pulse width modulator generates an output pulse having a width defined by the amplitude of the processed signal at the moment the clock pulse occurs. The pulse width of the output pulse defines the activation duration for an actuator 206 in the tactile sensation generator 110, e.g., the longer the pulse width the longer the vibration time.

The oscillator 410 generates a clock signal for the pulse width modulator 400. Typically, the clock signal has a fixed, nominal pulse rate that is slightly longer than the maximum possible duration of an output pulse of the pulse width modulator. The clock rate is optionally adjustable from the minimum clock pulse spacing (e.g., slightly longer than the maximum possible duration of the modulator output pulse). By increasing the spacing between the clock pulses and having a fixed maximum duration for the output pulse of the modulator, the effective duty cycle of the pulse width modulator output pulse is reduced. For example, if the clock pulse spacing is doubled from its minimum rate and the modulator is currently producing maximum width pulses, the duty cycle is effectively halved by the clock pulse spacing increase, i.e., the output pulse of the modulator is generated for half the time between the clock pulses. In this manner, a player may adjust the intensity of the vibration to a comfortable level.

The output signal from the pulse width modulator 400 is used by the drive circuit 416 to turn on and off one or more actuators 206 in the tactile sensation generator 110. The drive circuit contains at least one transistor switch circuit 414. The transistor switch circuit 414, in response to the output pulse of the modulator 400 becomes activated, e.g., conducts current, such that the transistor circuit, once activated, allows current to pass through an actuator 206 to ground. In response, the actuator 206, e.g., a DC motor, vibrates. A pulse width modulator, such as the 555 timer, is generally capable of driving a single transistor to activate a single actuator. To enable the pulse width modulator to drive multiple transistor circuits 414, through 414, and multiple actuators 206, one or more buffer circuits 412, through 412, are typically provided between the transistor circuits and the pulse width modulator.

The drive circuit 416 causes the tactile sensation actuators 206 to generate a tactile sensation for the player in response to audio signals presently being generated by the video game. By adjusting the filtering of the equalizer, the preamplifier gain, and the oscillator clock rate, the player can tailor the responsiveness of the control system to any particular game or other audio source. In addition, by adjusting the DC bias, the player can generate constant background (i.e., low amplitude) tactile sensation such as constant vibration of a race car while idling. As such, the present invention provides superb virtual reality excitement for a video game player.

The foregoing disclosure focused upon the use of the invention to provide a virtual reality experience to a video game player. However, this is not the only application for the invention. For example, it is foreseeable that the invention could be used to provide therapeutic tactile sensations to injured persons, e.g., vibrating certain muscles during physical therapy. Also, the invention can be used as a device for the hearing impaired, e.g., as a warning device that provides a tactile sensation when a certain sound occurs nearby such as a car horn, warning sound, and the like. Furthermore, the invention could be used in conjunction with a voice analyzer to provide a hearing impaired person with a tactile sensation in response to certain spoken words.

Although various embodiments which incorporate the teachings of the present invention have been shown and

6

described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings.

What is claimed is:

1. Apparatus for generating a control signal for a tactile sensation generator comprising:

an audio signal processor for processing audio signals and generating a processed signal; and

a control signal generator, connected to said audio signal processor, for generating, in response to said processed signal, said control signal for controlling the tactile sensation generator.

2. The apparatus of claim 1 wherein said audio signal processor generates said processed signal in response to the frequency, amplitude and rate of change of said audio signal.

3. The apparatus of claim 2 wherein said audio signal processor further comprises an equalizer for selectively amplifying or attenuating selected frequency bands of said audio signal.

4. The apparatus of claim 3 wherein said equalizer further comprises a high pass filter, a low pass filter and a bandpass filter connected in parallel and having an output port of the high pass filter, the low pass filter and the bandpass filter connected to three respective inputs of a summing amplifier.

5. The apparatus of claim 1 wherein said signal processor further comprises a rectifier for rectifying said audio signal.

6. The apparatus of claim 5 wherein said signal processor further comprises a peak hold circuit for temporarily holding the peak amplitude of the rectified audio signal.

7. The apparatus of claim 6 wherein said peak hold circuit further comprises DC bias circuitry for applying a DC bias to the peak amplitude of the rectified audio signal.

8. The apparatus of claim 7 wherein said control signal generator further comprises a pulse width modulator for producing a control signal having a pulse width indicative of the amplitude of the sum of the DC bias and the peak amplitude of the rectified audio signal.

9. The apparatus of claim 8 wherein the pulse width of said control signal determines the on time for a tactile sensation generator.

10. The apparatus of claim 1 wherein said tactile sensation generator vibrates in response to said control signal.

11. The apparatus of claim 10 wherein said tactile sensation generator is a dc motor having an offset weight connected to a shaft such that, when energized by the control signal, the motor vibrates.

12. The apparatus of claim 1 wherein said audio signal is produced by a video game executing upon a microprocessor.

13. The apparatus of claim 1 further comprising an oscillator for generating timing signals for the control signal generator.

14. The apparatus of claim 13 wherein said oscillator has a variable frequency.

15. Apparatus for generating a control signal for a tactile sensation generator comprising:

a front end circuit for forming a composite audio signal from a stereophonic audio signal;

a variable gain preamplifier, connected to said front end circuit, for amplifying said composite audio signal;

an equalizer, connected to said preamplifier, for selectively filtering said amplified composite audio signal;

a rectifier, connected to said equalizer, for rectifying the equalized signal;

a peak hold circuit, connected to said rectifier, for temporarily holding the rectified signal and for adding a DC bias to the rectified signal to generate a processed signal; and

5,684,722

7

a control signal generator, connected to said peak hold circuit, for generating, in response to said processed signal, a control signal for said tactile sensation generator.

16. The apparatus of claim 15 wherein said control signal generator further comprises a pulse width modulator for generating a control signal having at least one pulse whose pulse width is indicative of the amplitude of the processed signal.

17. The apparatus of claim 16 wherein said control signal generator further comprises an oscillator for producing a variable clock rate for said pulse width modulator to adjust a duty cycle of said control signal.

18. A method of generating a control signal for a tactile sensation generator comprising the steps of:

processing an audio signal to generate a processed signal; and

generating, in response to said processed signal, said control signal for said tactile sensation generator.

19. The method of claim 18 wherein said audio signal processing step further comprises the step of generating said processed signal in response to the frequency, amplitude and rate of change of said audio signal.

20. The method of claim 18 wherein said audio signal processing step further comprises the step of equalizing said audio signal by selectively amplifying or attenuating selected frequency bands of said audio signal.

21. The method of claim 18 wherein said audio signal processing step further comprises the step of rectifying said audio signal.

22. The method of claim 21 wherein said audio signal processing step further comprises the step of temporarily holding a peak amplitude of the rectified audio signal.

8

23. The method of claim 22 wherein said holding step further comprises applying a DC bias to the peak amplitude of the rectified audio signal.

24. The method of claim 23 wherein said control signal generating step further comprises the step of producing a control signal having a pulse width indicative of the amplitude of the sum of the DC bias and the peak amplitude of the rectified audio signal.

25. The method of claim 18 wherein said tactile sensation generator vibrates in response to said control signal.

26. A method of generating a control signal for a tactile sensation generator comprising the steps of:

forming a composite audio signal from a stereophonic audio signal;

amplifying said composite audio signal;

selectively filtering said amplified composite audio signal;

rectifying the equalized signal;

temporarily holding the rectified signal and for adding a DC bias to the rectified signal to generate a processed signal; and

generating, in response to said processed signal, a control signal for said tactile sensation generator.

27. The method of claim 26 wherein said control signal generating step further comprises the step of generating a control signal having at least one pulse whose pulse width is indicative of the amplitude of the processed signal.

* * * * *

EXHIBIT B



US005669818A

United States Patent [19][11] **Patent Number:** **5,669,818****Thorner et al.**[45] **Date of Patent:** **Sep. 23, 1997****[54] SEAT-BASED TACTILE SENSATION GENERATOR**

[76] **Inventors:** **Craig Thorner**, 16 Nantucket Ct.,
Howell, N.J. 07731; **Thomas K. Glass**,
277 Frank Applegate Rd., Jackson, N.J.
08527

5,299,810 4/1994 Pierce et al. 273/434
5,368,484 11/1994 Copperman et al. 343/69
5,513,129 4/1996 Bolas et al. 364/578
5,553,148 9/1996 Werde 381/151

Primary Examiner—Jessica Harrison*Assistant Examiner*—James Schaaf*Attorney, Agent, or Firm*—Thomason & Moser[21] **Appl. No.:** **409,327**[22] **Filed:** **Mar. 23, 1995**[51] **Int. Cl.⁶** **A63F 9/22**[52] **U.S. Cl.** **463/30; 463/47**

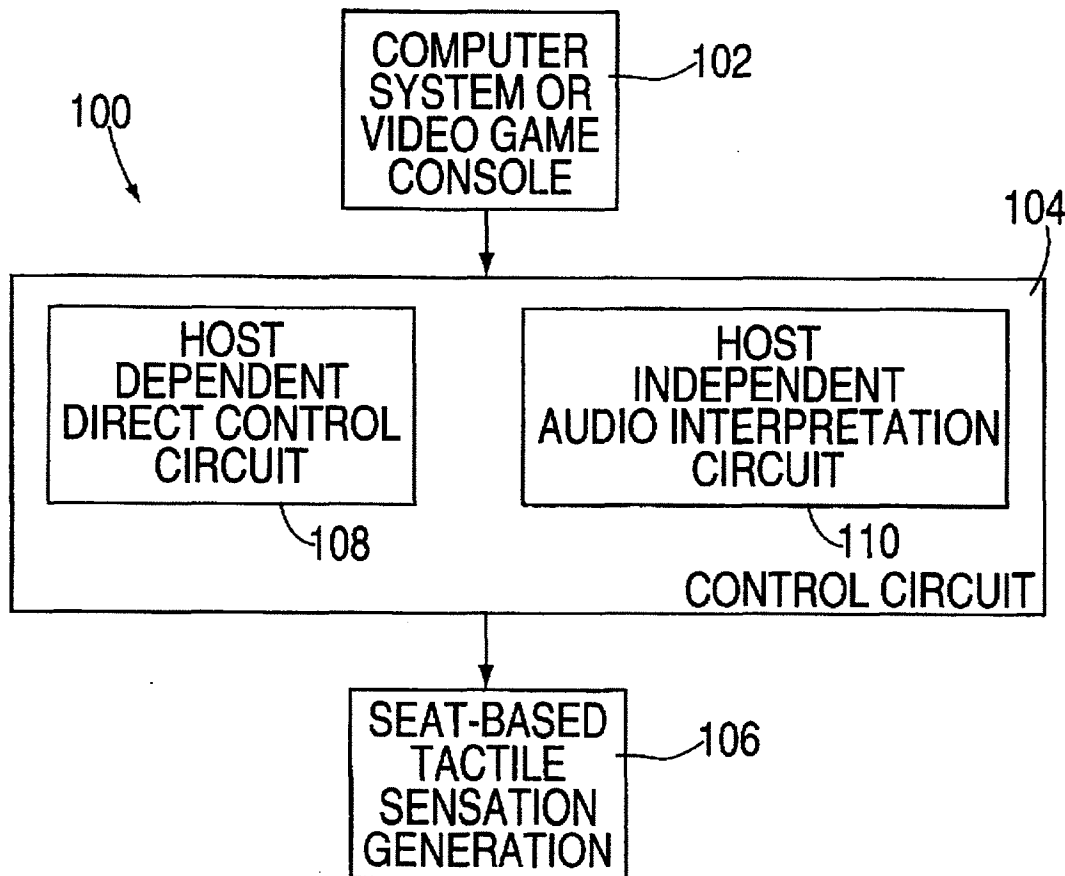
[58] **Field of Search** 273/434, 460,
273/198 B; 434/114; 340/407.1; 463/30,
47

[56] References Cited**U.S. PATENT DOCUMENTS**

3,902,687 9/1975 Hightower 340/407.1
4,484,191 11/1984 Vavra 340/407.1
4,574,391 3/1986 Morishima 381/18
4,771,344 9/1988 Fallacaro et al. 273/460
5,203,563 4/1993 Loper, III 273/148 B

[57] ABSTRACT

A seat-based tactile sensation generator capable of producing tactile sensation to a video game player corresponding to activity portrayed in a video game. Specifically, in response to signals produced by the video game, a control circuit generator produces control signals for the seat-based tactile sensation generator. The tactile sensation generator contains an array of actuators embedded within a foam seating pad. A specific arrangement of actuators positions the actuators proximate particular portions of a game player's body. Each actuator or group of actuators interacts with the player and is individually activated to produce a localized tactile sensation, e.g., an impact or vibration, corresponding to the action portrayed by the video game as it occurs.

35 Claims, 8 Drawing Sheets

U.S. Patent

Sep. 23, 1997

Sheet 1 of 8

5,669,818

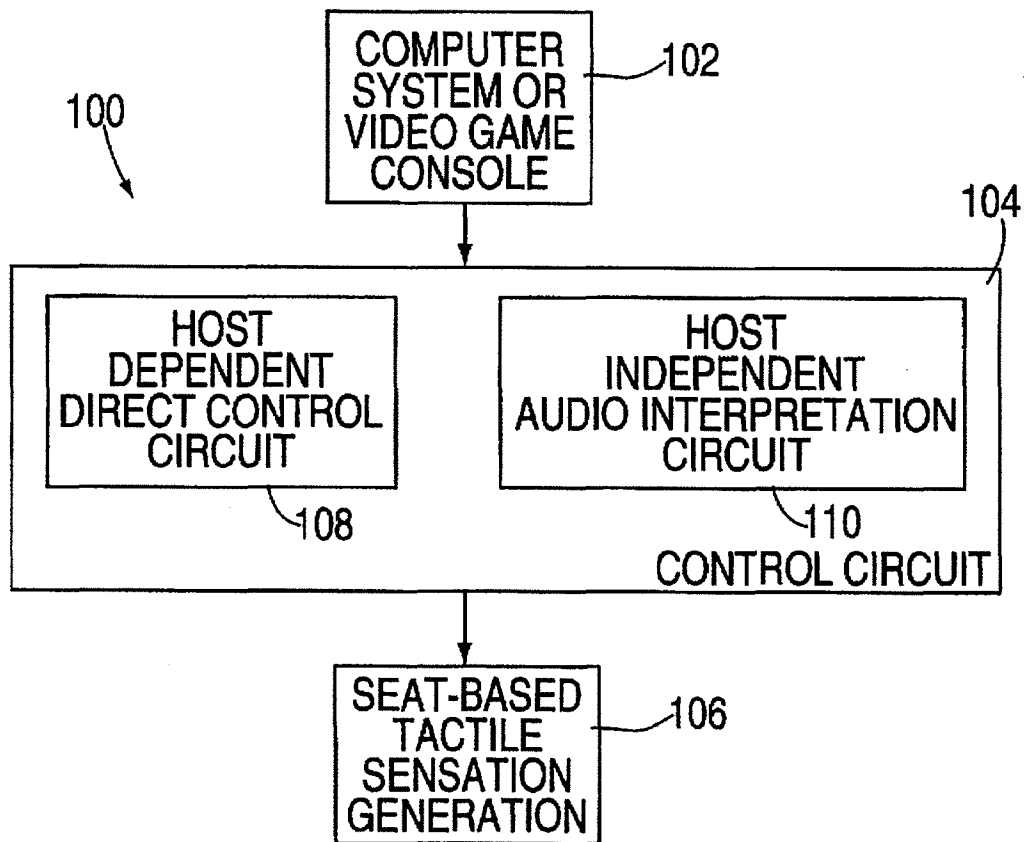


FIG. 1

U.S. Patent

Sep. 23, 1997

Sheet 2 of 8

5,669,818

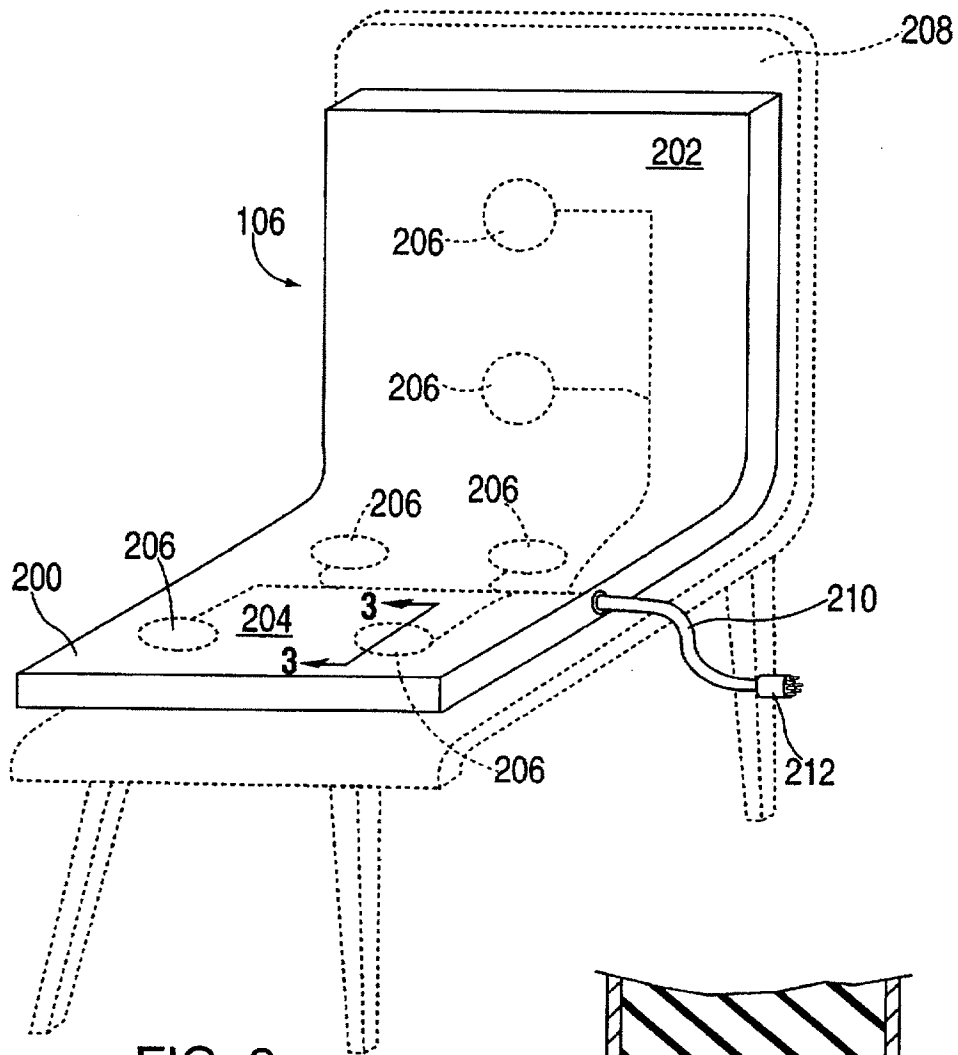


FIG. 2

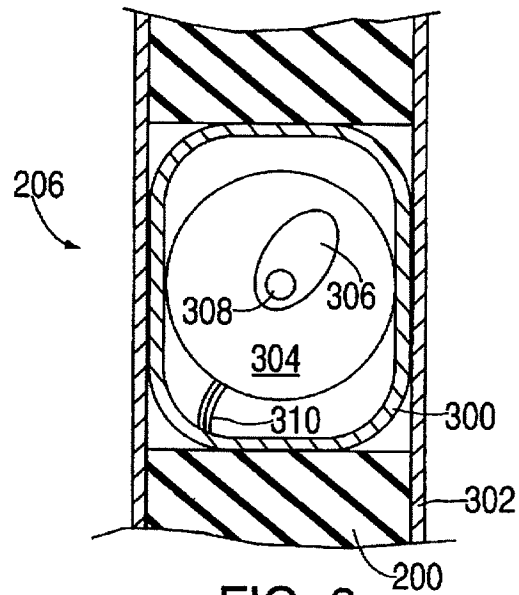


FIG. 3

U.S. Patent

Sep. 23, 1997

Sheet 3 of 8

5,669,818

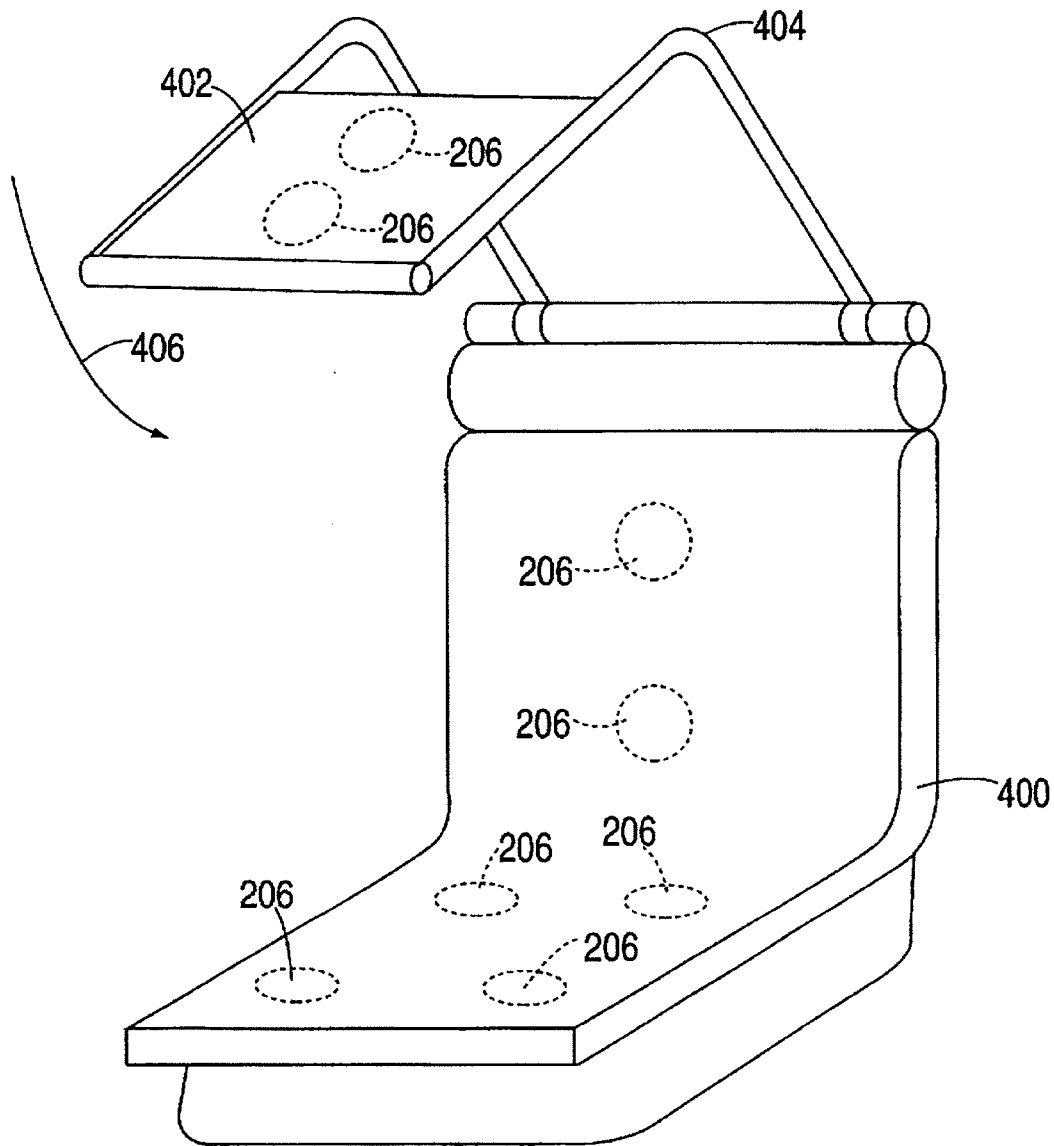


FIG. 4

U.S. Patent

Sep. 23, 1997

Sheet 4 of 8

5,669,818

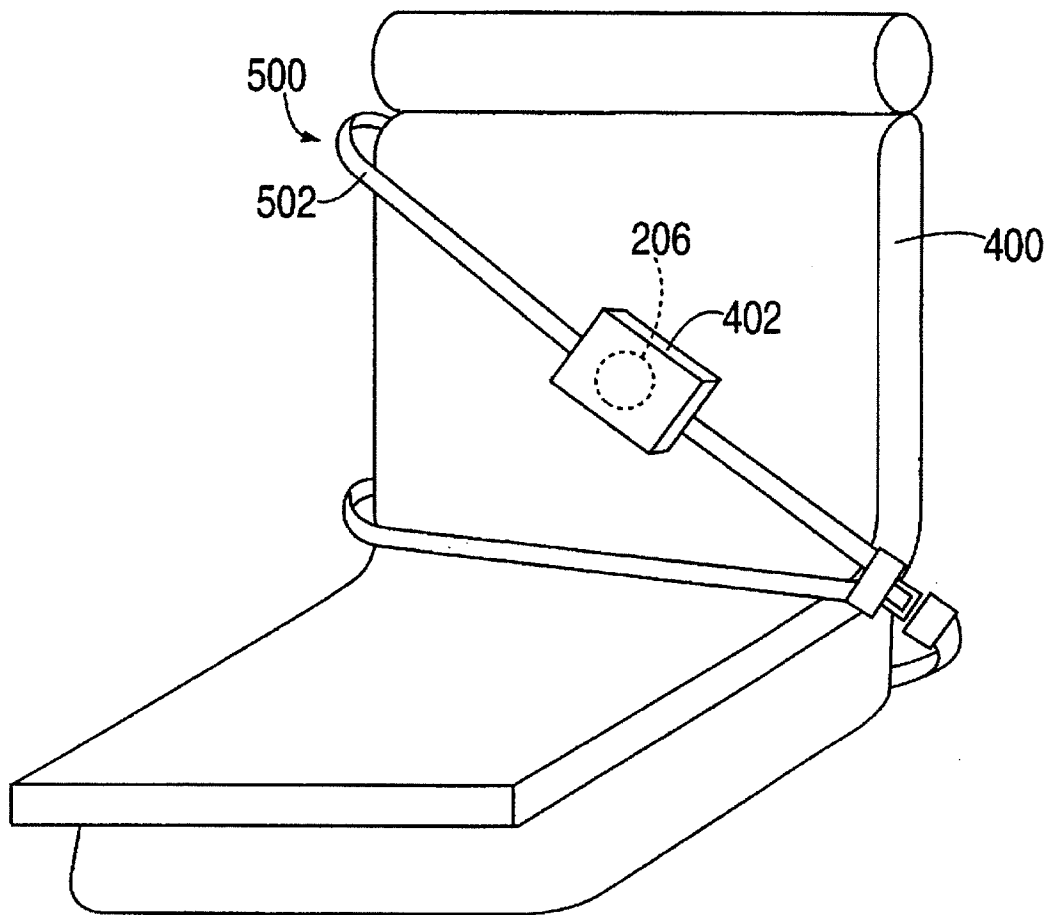


FIG. 5

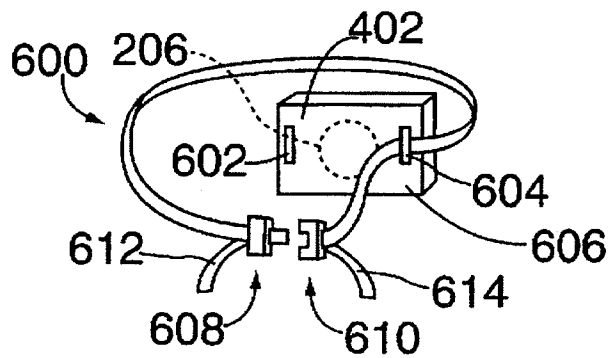


FIG. 6

U.S. Patent

Sep. 23, 1997

Sheet 5 of 8

5,669,818

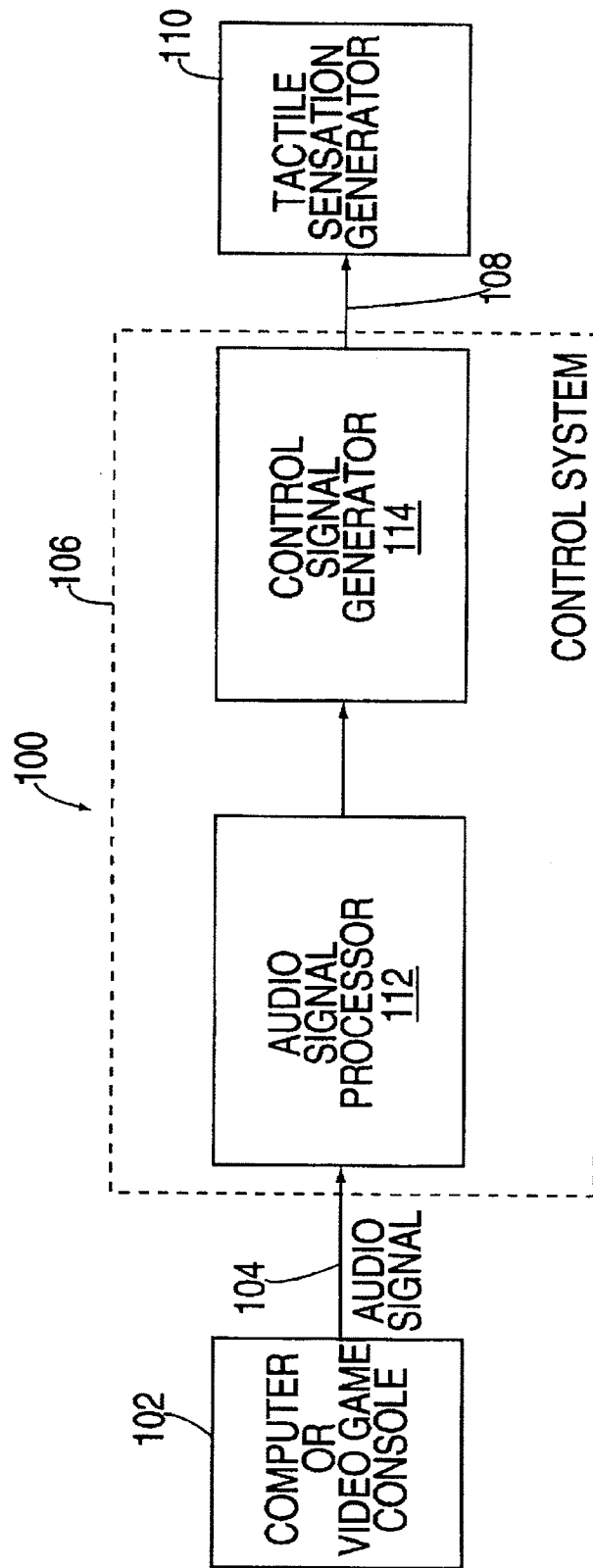


FIG. 7

U.S. Patent

Sep. 23, 1997

Sheet 6 of 8

5,669,818

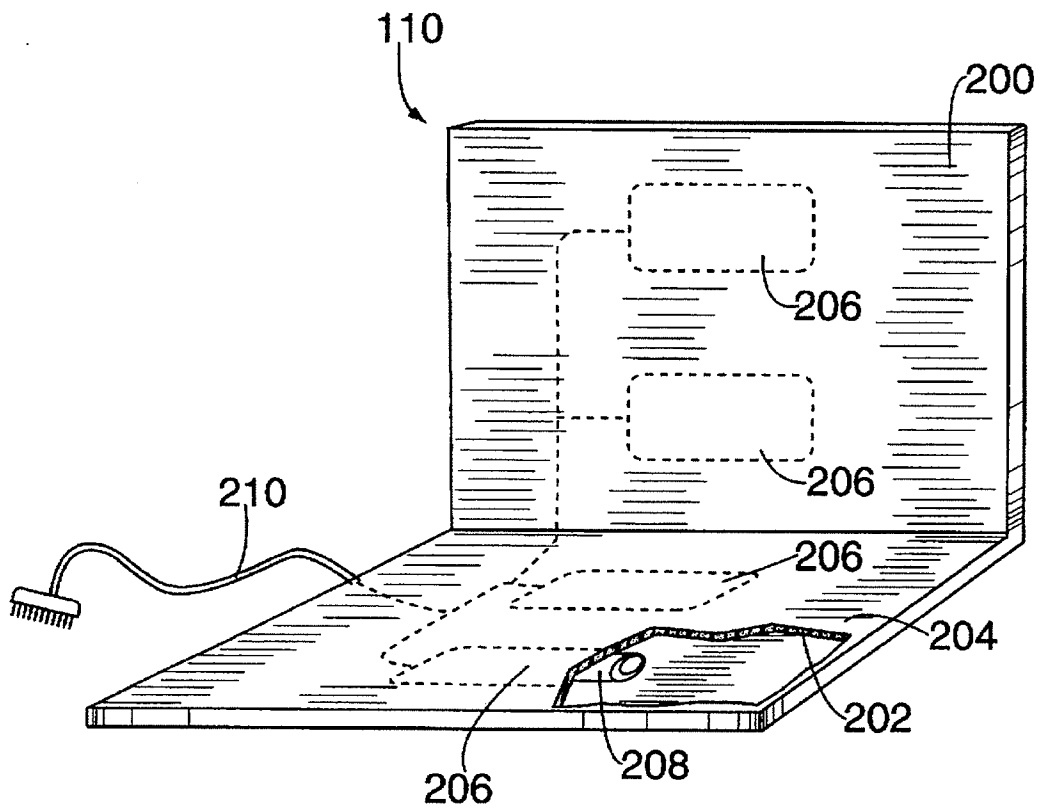


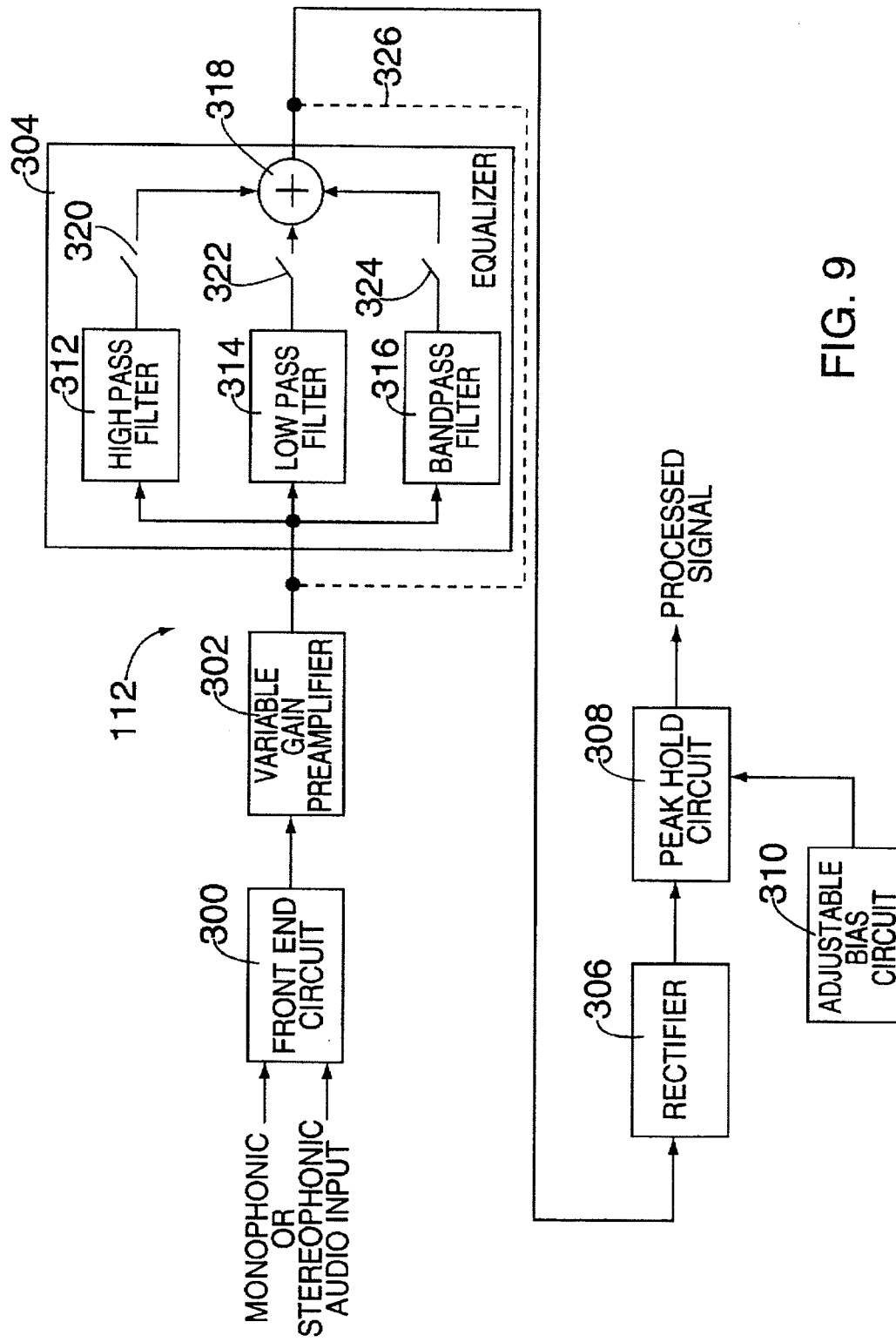
FIG. 8

U.S. Patent

Sep. 23, 1997

Sheet 7 of 8

5,669,818



U.S. Patent

Sep. 23, 1997

Sheet 8 of 8

5,669,818

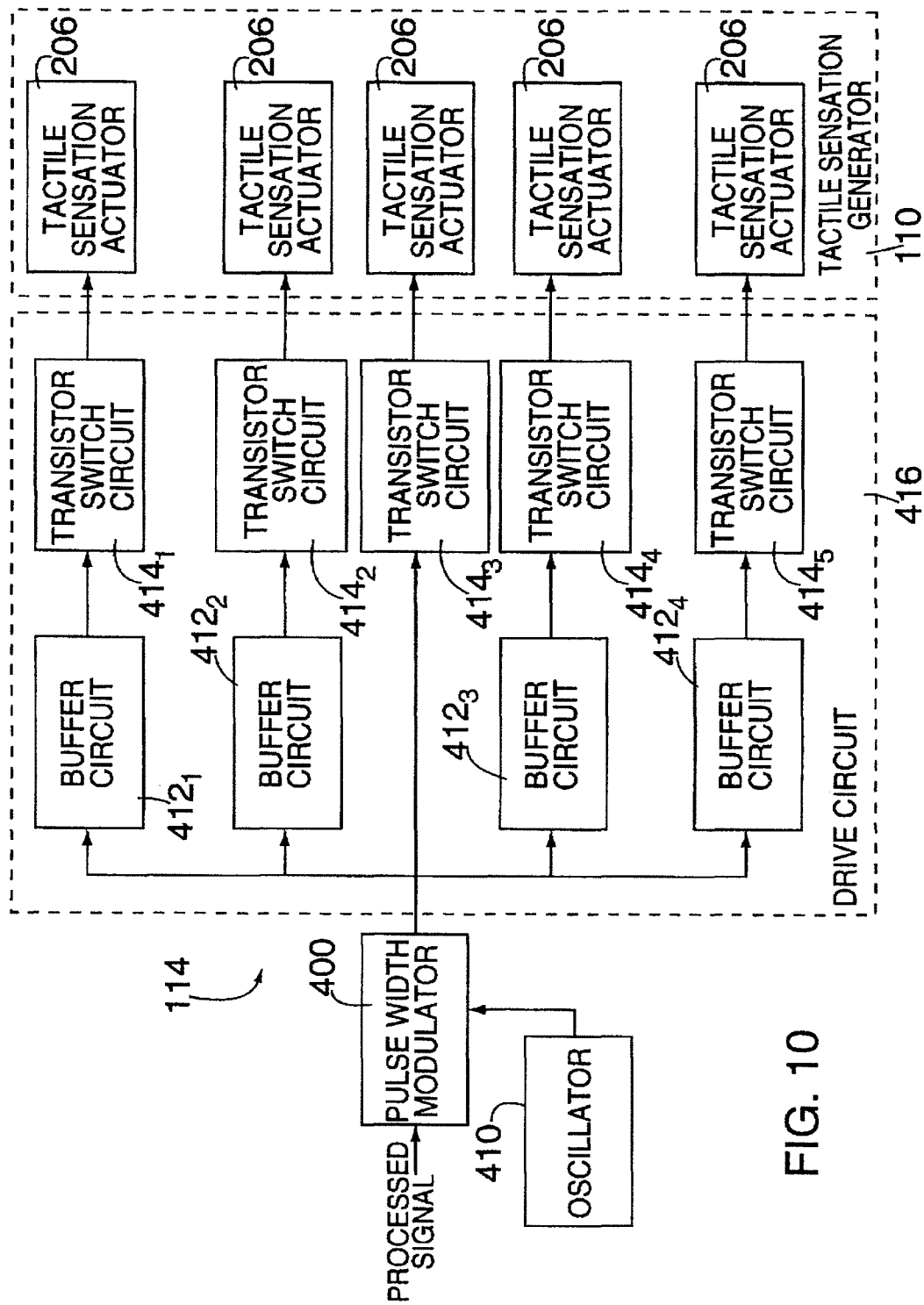


FIG. 10

5,669,818

1

SEAT-BASED TACTILE SENSATION GENERATOR

BACKGROUND OF THE DISCLOSURE

1. Field of the Invention

The invention relates to virtual reality computer systems and, more particularly, to a tactile sensation generator within a virtual reality computer system or virtual reality computer game.

2. Description of the Background Art

Video games are typically executed by microprocessors within dedicated game consoles or computers such that a player interactively manipulates a video game scene as displayed on a video monitor or television using a keyboard, mouse, joystick, or some other command input device. In addition to the video output, most game apparatus also produces an audio output that corresponds to the scene presently displayed on the monitor. In this manner, a player is exposed to both auditory and visual sensation from the game apparatus.

Although today's audio-visual game experience is exciting, the excitement is limited by the game's inability to produce any form of tactile sensation corresponding to the scene being displayed. Generally, tactile sensation, such as vibration, vehicle acceleration, crashes, and the like, have not been simulated with any great success. In one available tactile sensation generator, a modified audio speaker is positioned below a player's seat such that low frequencies in an audio signal applied to the modified speaker vibrate the seat. In such a system, the sound volume of the game must be very loud to achieve a significant sensation of vibration, and the tactile sensation only corresponds to the audio signal.

Alternatively, tactile sensation has been provided by hydraulic and pneumatic systems. However, full motion hydraulic and pneumatic systems are very expensive and bulky, requiring extensive maintenance and a significant amount of floor space. These systems are far too complex and impractical for widespread use.

Therefore, a need exists in the art for a seat-based tactile sensation generator capable of implementing control signals supplied by a video game such that the tactile sensation generator produces tactile sensation corresponding to the activity portrayed on a computer monitor by the game apparatus.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of the prior art by providing a seat-based tactile sensation generator capable of producing tactile sensations for a video game player corresponding to an activity portrayed by game apparatus. Specifically, the inventive generator operates in response to control signals generated by a control circuit. The control circuit is either responsive to control commands generated by a computer or video game console executing the video game program, or by a computer or game system operating in combination with an AudioSense™ control signal generator. AudioSense is a trademark of Virtual Reality Feedback Corporation. The AudioSense control signal generator is the subject of U.S. patent application Ser. No. 08/309,763, filed Sep. 21, 1994. The control circuit interprets the control commands (or audio signals) and activates the seat-based tactile sensation generator in the appropriate fashion to simulate the action occurring on the monitor.

2

The seat-based tactile sensation generator is composed of an array of actuators arranged within a foam seat cushion. More specifically, the actuators are motors with offset weights that vibrate a player's body in a specified pattern and intensity, or solenoids that provide jolting effects. The actuators are individually imbedded (or attached) to a foam pad fabricated to conform to a chair or seat. In this manner, the actuators can be arranged within the pad to contact specific portions of a player's body. Illustratively, a back portion of the seat-shaped foam pad contains two actuators, and a bottom portion of the pad contains four actuators arranged to contact the buttocks and each leg of a user. Each actuator is independently actuated by the control circuit to provide a localized tactile sensation.

In an alternative embodiment of the invention, the actuators may be integrated permanently into a given seating system. Such an embodiment finds use as a seat for an arcade-type video game. Furthermore, a chest pad can be added to further provide tactile sensation to the chest of a user. The chest pad is a foam pad containing one or more actuators. The chest pad is either held to the chest by a harness or by an overhead mechanism that pivots to position the chest pad into place.

BRIEF DESCRIPTION OF THE DRAWINGS

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 depicts a high level block diagram of a virtual reality computer system connected to a seat-based tactile sensation generator;

FIG. 2 depicts a perspective view of the seat-based tactile sensation generator;

FIG. 3 is a cross-sectional view of an actuator within the seat-based tactile sensation generator of FIG. 2.

FIG. 4 is a perspective view of an alternative embodiment of the seat-based tactile sensation generator.

FIG. 5 is a perspective view of a seat-based tactile sensation generator having a three-point seat belt system; and

FIG. 6 is a perspective view of a harness for maintaining an actuator chest portion in contact with a user's chest.

FIG. 7 depicts a high level block diagram of a tactile sensation generation system;

FIG. 8 schematically depicts an illustrative tactile sensation generator;

FIG. 9 depicts a detailed block diagram of the audio signal processor of FIG. 7; and

FIG. 10 depicts a detailed block diagram of the control signal generator of FIG. 7.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

FIG. 1 depicts a high level block diagram of a virtual reality computer system 100 containing a computer system 102, a control circuit 104, and a seat-based tactile sensation generator array 106. The computer system 102 is a conventional home computer capable of executing various computer game programs. Alternatively, a dedicated video game console or an arcade-type video game system can be substituted for the computer system. Hereinafter, the game

5,669,818

3

console or computer system 102 is generally referred to as host system or merely as a host. As the host executes the game programs, the programs generate signals that are used by the control circuit to control the tactile sensation generator 106.

The control circuit 104 is either a host dependent direct control interface circuit 108 or a host independent audio-interpretation circuit 110. The host dependent direct control interface circuit 108 implements specific control commands generated by the executing program and made available to the control circuit via the parallel or serial part of the host. These commands are designed specifically to produce certain tactile sensation at particular points during the program's execution. On the other hand, the host independent audio interpretation circuit 110 analyzes an audio signal generated by the host and generates tactile sensation control signals in response to the audio signal. Such an audio interpretation circuit is disclosed in U.S. patent application Ser. No. 08/309,763, filed Sep. 21, 1994 and herein described below. Circuits 108 and 110 can be alternatively used or used in combination.

The seat-based tactile sensation generator 106 converts these control signals into tactile sensations corresponding to a present game scene portrayed on some visual system, e.g., a conventional computer monitor or television, or a stereoscopic tracking headset. These control signals activate one or more actuators in an actuator array within the tactile sensation generator to simulate any type of stimulus imposed upon a specific character or vehicle within the game scene. In a seat-based tactile sensation generator, the tactile stimulus simulates vehicle acceleration, deceleration, vibration, shaking, crashes, collisions, and the like.

FIG. 2 depicts a three-quarter perspective view of a seat-based tactile sensation generator 106 positioned upon a conventional chair 208 (shown in phantom). Although the seat-based tactile sensation generator is illustratively depicted as interfitting a conventional chair, the generator may alternatively be formed in the shape of a motorcycle seat, aircraft cockpit and the like. In whatever physical shape, in response to control signals from the control circuit, the tactile sensation generator induces tactile sensation into a person in contact with the actuator array within the generator.

Specifically, the illustrative generator 106 contains a substantially unitary flexible pad 200 having an upper portion 202 and a lower portion 204 that respectively contact the back and legs of a person seated upon the generator. The flexible pad is typically fabricated from a foam sheet such as neoprene. The pad conforms to the body of a user and to a chair upon which it is placed. The flexible pad 200 has a plurality of actuators 206 imbedded or attached thereto. In the seat based actuator array, gravity insures that the sensation generated by any given actuator 206 contacts a part of a player's body. As such, the sensation is transmitted to a player's body.

The actuators 206 are attached to or embedded within the surface of the pad. These actuators can be solenoids, piezo-electric actuators, electro-mechanical buzzers, vibrating motors, and the like, of any combination thereof. When using solenoids, an aperture is provided through the pad such that the moveable portion of the solenoid can impact the player. For illustrative purposes, the remainder of this disclosure describes the use of electric motors as actuators. Those skilled in the art will realize from this disclosure that any other form of actuator is contemplated for use as a component of this seat-based tactile sensation generator. The

4

actuator control signals from the control circuit are connected to the generator 106 via cable and/or wiring harness 210. To ensure portability of the seat-based generator, the harness 210 is connected to the control circuit via a detachable plug 212.

Although any number of actuators in any arrangement is within the scope of this invention, the illustration shows six actuators 206 arranged such that two actuators are located in upper portion 202 and four actuators are located in lower portion 204. The four lower actuators are further arranged such that two actuators contact a user's buttocks, one actuator contacts a user's right leg and one actuator contacts a user's left leg. Furthermore, the tactile sensation generator 106 is divided into three zones. Specifically, the zones (defined while facing the seat-based tactile sensation generator) include left lower portion (right buttock and right leg actuators), a right lower portion (left buttock and left leg actuators), and an upper portion (back actuators). Each zone can be controlled as well as each individual actuator. Additionally, an external fourth zone (a chest portion) is optionally available as described in detail below with respect to FIGS. 4, 5, and 6.

The various commands from the host specify which of the actuators (or groups of actuators) shall be independently energized to simulate the game activity portrayed upon the computer monitor. As such, the game player experiences tactile sensations that simulate the various physical elements that are portrayed in the video game.

FIG. 3 depicts a cross-sectional view of an actuator 206 taken along line 3—3 in FIG. 2. The actuator is encased in a housing 300, typically fabricated of aluminum or hard plastic. A cloth, vinyl, or other covering material 302 is attached, by an adhesive or by sewing, to the surface of the pad 200. The illustrative actuator that is depicted is an electric motor 304 having an offset weight 306 attached to its shaft 308. When energized, the electric motor 304 with an offset shaft weight vibrates, thus, providing a tactile sensation to a person that is in contact with the motor or its housing. Wires 310 provide control signals and power to the motor.

In operation, the control circuit selects one or more actuators and applies an electric current to the selected actuator(s). In one illustrative implementation of a command structure, the parallel port of the host is used as the source of commands. Alternatively, a serial port could be used or the control circuit could be implemented on a circuit card for connection to a parallel bus within the host. The game program, as it executes on the host, is assumed to generate the appropriate command for the tactile sensation generator at the appropriate time.

FIG. 4 depicts a perspective view of an alternative embodiment of the invention where the seat-based tactile sensation generator is an integral portion of a seating system 400. Such a seating system has an illustrative use within an arcade-type video game, a movie theater seat, and the like. This stationary system functions identical to the portable system discussed above.

A further alternative to either system is a chest portion. The chest portion 402 contains one or more actuators 206 that, when activated, produce a tactile sensation on the chest of a user. The actuators are generally incorporated into the chest portion in the same manner as described above for incorporating actuators into the seating system. In the stationary seating system of FIG. 4, the chest portion 402 is attached to a harness 404 that is much like an overhead harness for a roller coaster. In use, the player pulls down the

5,669,818

5

harness (along arrow 406) into a position that places the actuator(s) in the chest portion in contact with his or her chest.

FIG. 5 depicts a perspective view of an alternative attachment for the chest portion 402. In this alternative embodiment, the chest portion 402 is centrally attached to a three-point seat belt system 500. The seat belt system is, in turn, attached to the stationary seating system 400. Specifically, the chest portion 402 attaches to a shoulder strap 502 of the seat belt system 500 such that portion 402 is maintained against the user's chest.

FIG. 6 depicts a further alternative attachment of the chest portion 402. In this embodiment, the chest portion 402 is attached by a belt harness 600. The harness has a single belt which circumscribes a user's chest and maintains the chest portion of the tactile sensation generator against the user's chest.

The illustrative belt harness depicted in FIG. 6 has two fabric loops 602 and 604 affixed, by stitching or glue, to an outer surface 606 of chest portion 402. A flexible, typically fabric, belt is threaded through loop 604. Buckles (male 608 and female 610) are respectively attached to belt ends 612 and 614. During use buckle 608 and end 612 are threaded through loop 602. The buckles are moveable with respect to the belt such that, once buckled, a user can pull outwardly on belt ends 612 and 614 to tighten the chest portion 402 against their chest. Friction of the belt passing through the buckles maintains the belt in a tightened position such that the chest portion remains in contact with the user's chest. A chest portion that is strapped to a user via a multiple-belt shoulder harness is described in U.S. patent application 08/309,764, filed Sep. 21, 1994 and herein incorporated by reference.

Although various embodiments which incorporate the teachings of the present invention have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings.

FIG. 7 depicts a high level block diagram of a tactile sensation generation system 100 containing a computer system or video game console 102, a tactile sensation generator 110 and a control system 106 for the tactile sensation generator 110. The control system 106 further contains an audio signal processor 112 and a control signal generator 114. The home computer 102 may, of course, be replaced with any device that produces an audio signal such as a video game console, stereo system, television receiver, microphone, and the like. However, for simplicity, throughout this disclosure, it is assumed that the audio source is a conventional home computer executing a video game program. As such, the control system 106 converts the audio signals conventionally generated by the video game into control signals for the tactile sensation generator.

More specifically, the computer 102 has its audio output port, e.g., an earphone jack, connected, via line 104, to audio signal processor 112 within the control system 106. In general, the signal processor analyzes the frequency, amplitude, and rate of change of the audio signal produced by the currently executing video game. From the analysis of the audio signal, the audio signal processor 112 produces a processed signal. The processed signal forms an input to the control signal generator 114 which produces a control signal, on line 108, for the tactile sensation generator 110.

The tactile sensation generator can be one or more devices (actuators) capable of simulating vibration, punches, bullet strikes and the like in accordance with specific control

6

signals. Consequently, while using the inventive apparatus, a player experiences a virtual reality while interacting with the video game. To provide a full understanding of the invention, a detailed example of a tactile sensation generator is provided below.

FIG. 8 depicts one example of a tactile sensation generator 110 capable of being controlled by the control system 106. Specifically, the tactile sensation generator contains a seat pad 200 having localized vibration producing actuators 206 distributed within the pad. The seat pad 200 is a foam cushion 202 enclosed in a cloth cover layer 204. Beneath the cover layer 204 are electric motors having offset weights mounted to their shafts. One such motor 208 is depicted in FIG. 8. When activated by control signals applied via wires 210, the shafts of the motors rotate and the offset weights cause the motors to vibrate. The depicted seat has four such vibrating motors. A seat pad of this type is available as model 905 from JB Research of Los Angeles, Calif. Although tactile sensation is generated in this example by vibrating electric motors, those skilled in the art will realize that any type of vibrating actuator may be used in lieu of motors including buzzers, solenoids, piezo-electric actuators, and the like. Also, any number of actuators can be used, i.e., one or more actuators. Furthermore, the tactile sensation actuators do not have to be vibratory. It is foreseeable that other forms of generators such as solenoids could be used to poke and prod a player with a single strike when a bullet or fist impact is to be simulated.

Using the seat pad described above, a video game such as an auto racing game produces simulated vibration as a player's video game car accelerates, e.g., increased vibration with engine revs (higher pitched sound). The amplitude and frequency of the vibration is changed as the video car changes speed. Also, impacts with obstacles that are evidenced by low frequency, high amplitude audio signals result in forceful, high-frequency vibrations throughout the seat pad. Consequently, while playing the video game, a player receives a tactile sensation of actually sitting in a race car. To enhance the virtual reality effect, vibrating wrist and/or ankle tactile sensation generators can be applied to the player in addition to the seat pad. In accordance with the teachings of the present invention, the control system 106 produces control signals for the vibration actuators 206.

FIG. 9 depicts a detailed block diagram of the audio signal processor 112. In general, the input to processor 112 is an audio signal from an audio source, any audio source. The signal may be either stereophonic or monophonic. The processor 112 responds to the pitch (frequency), volume (amplitude) and rate of change of the audio signal by producing a processed signal indicative of these characteristics of the input audio signal.

Specifically, the audio signal processor 112 contains a front end circuit 300, a preamplifier 302, an equalizer 304, a rectifier 306, a peak hold circuit 308, and an adjustable bias circuit 310. These major components are more or less connected in series.

More specifically, the front end circuit 300 contains a mixer for combining both channels of a stereophonic audio signal to form a composite audio signal, a high pass filter for limiting noise that is below of the audio band, e.g., lower than 20 Hz, and a diode signal limiter for limiting (clipping) the amplitude of the input signal to protect the audio signal processor from being damaged by overly powerful input audio signals. Circuitry 300 is connected to a variable gain preamplifier 302.

The variable gain preamplifier 302 establishes the dynamic range of the entire audio signal processor 112. For

5,669,818

7

instance, if the gain of the preamplifier is set to high, any loud (high amplitude) signals would saturate the processor and, as such, not create the desired tactile sensation. On the other hand, if the preamplifier gain is set too low, low amplitude audio signals would not generate any tactile sensation and only high amplitude signals would cause a tactile response. Consequently, a player must adjust the gain of the preamplifier to conform to audio signal levels generated by the game currently being played. In other words, the specific gain setting depends upon the dynamic range of input audio signal and the player's tactile sensation preferences. Illustratively, the voltage gain of the preamplifier is variable from no gain to a 1000 times. In some applications where the audio signal has a low amplitude, additional fixed gain amplification may be necessary before and/or after the variable gain preamplifier.

Once amplified, the audio signal forms an input to the equalizer 306. The equalizer contains three parallel connected filters: a high pass filter 312, a low pass filter 314, and an bandpass filter 316. The high pass filter has an illustrative passband of 2 kHz to 13 kHz, the low pass filter has an illustrative passband of 28 Hz to 350 Hz, and the bandpass filter has a passband of 230 Hz to 10.3 kHz. The three paths each form an input to a summing amplifier 318. Additionally, each of the three paths has a switch (switches 320, 322, and 324) to select one or more of the paths as an input to the summing amplifier 318. As such, depending on which of the signal paths are connected to the summing amplifier, the equalizer can selectively amplify or attenuate low frequencies, high frequencies or both. As such, a game player can adjust the frequency content of the audio that is used to generate tactile sensation generator control signals and, consequently, tailor the tactile sensation to the game being executed.

Nonetheless, the equalizer 304 is an optional circuit for the invention. The equalizer permits optimizing the tactile sensation to a audio source, e.g., the equalizer enables a video game player to exclude the background music of the game from the audio signal that produces a tactile sensation. Therefore, if such additional flexibility is not desired, the equalizer can be deleted.

The rectifier 306 is provided to produce a positive signal from the bi-polar filtered audio signal. The peak hold circuit 308 responds quickly to the peak amplitude of the rectified signal, but slowly decays from that peak amplitude. Specifically, the peak hold circuit contains a parallel combination of a capacitor and a resistor. The capacitor charges as the rectified audio signal is applied thereacross. The resistor has a very large resistance, e.g., 10M Ω , such that the capacitor (0.022 μ F) discharges slowly through the resistance. As a result, the capacitor temporarily holds the peak amplitude of the rectified audio. The voltage level on the capacitor forms an input to a high impedance voltage amplifier. This implementation of the peak circuit samples both the frequency and amplitude of the rectified audio signal, i.e., when either the frequency or amplitude of the input signal change, the output signal will change to some degree. As such, the output of the peak hold circuit contains information pertaining to the frequency and amplitude of the rectified signal.

The specific time constant of this RC circuit is defined by the response time of the actuators used in the tactile sensation generator. For example, the response of electric motors is rather slow; therefore, the resonant frequency of the RC circuit would be approximately 90 Hz. In contrast, if the actuators in the tactile sensation generator are piezo-electric actuators; then, the resonant frequency of the RC circuit would be on the order of a thousand hertz or more.

8

Also, a DC bias voltage, generated by adjustable bias circuit 310, is added to the peak held signal such that the amplifier output signal is a composite (sum) of the peak held signal and the DC bias value. The bias value is a player adjustable offset. The utility of this DC bias is discussed below. The biased and amplified peak held signal is hereinafter referred to as a processed signal.

FIG. 10 depicts a detailed block diagram of the control signal generator 114. Specifically, the control signal generator contains a pulse width modulator 400, an oscillator 410, and drive circuit 416 for the tactile sensation generator 110. The processed signal forms an input to the pulse width modulator 400, e.g., a conventional 555 timer. Those skilled in the art will realize from this disclosure that other forms of modulation such as frequency modulation are also useful in lieu of pulse width modulation.

The pulse width modulator generates a pulse having a width that corresponds to the amplitude of the input signal to the pulse width modulator. As such, if a constant DC voltage level (e.g., the DC bias discussed above) forms an input to the pulse width modulator, the modulator will generate an output pulse having a pulse width indicative of the amplitude of that DC signal. When an AC signal forms the input to the modulator (e.g., the processed signal), each output pulse from the modulator has a duration that is indicative of the instantaneous amplitude of the AC signal sampled at the clock rate. As such, for each clock pulse, the pulse width modulator generates an output pulse having a width defined by the amplitude of the processed signal at the moment the clock pulse occurs. The pulse width of the output pulse defines the activation duration for an actuator 206 in the tactile sensation generator 110, e.g., the longer the pulse width the longer the vibration time.

The oscillator 410 generates a clock signal for the pulse width modulator 400. Typically, the clock signal has a fixed, nominal pulse rate that is slightly longer than the maximum possible duration of an output pulse of the pulse width modulator. The clock rate is optionally adjustable from the minimum clock pulse spacing (e.g., slightly longer than the maximum possible duration of the modulator output pulse). By increasing the spacing between the clock pulses and having a fixed maximum duration for the output pulse of the modulator, the effective duty cycle of the pulse width modulator output pulse is reduced. For example, if the clock pulse spacing is doubled from its minimum rate and the modulator is currently producing maximum width pulses, the duty cycle is effectively halved by the clock pulse spacing increase, i.e., the output pulse of the modulator is generated for half the time between the clock pulses. In this manner, a player may adjust the intensity of the vibration to a comfortable level.

The output signal from the pulse width modulator 400 is used by the drive circuit 416 to turn on and off one or more actuators 206 in the tactile sensation generator 110. The drive circuit contains at least one transistor switch circuit 414₃. The transistor switch circuit 414₃, in response to the output pulse of the modulator 400 becomes activated, e.g., conducts current, such that the transistor circuit, once activated, allows current to pass through an actuator 206 to ground. In response, the actuator 206, e.g., a DC motor, vibrates. A pulse width modulator, such as the 555 timer, is generally capable of driving a single transistor to activate a single actuator. To enable the pulse width modulator to drive multiple transistor circuits 414₁ through 414₅ and multiple actuators 206, one or more buffer circuits 412₁ through 412₄ are typically provided between the transistor circuits and the pulse width modulator.

5,669,818

9

The drive circuit 416 causes the tactile sensation actuators 206 to generate a tactile sensation for the player in response to audio signals presently being generated by the video game. By adjusting the filtering of the equalizer, the pre-amplifier gain, and the oscillator clock rate, the player can tailor the responsiveness of the control system to any particular game or other audio source. In addition, by adjusting the DC bias, the player can generate constant background (i.e., low amplitude) tactile sensation such as constant vibration of a race car while idling. As such, the present invention provides superb virtual reality excitement for a video game player.

The foregoing disclosure focused upon the use of the invention to provide a virtual reality experience to a video game player. However, this is not the only application for the invention. For example, it is foreseeable that the invention could be used to provide therapeutic tactile sensations to injured persons, e.g., vibrating certain muscles during physical therapy. Also, the invention can be used as a device for the hearing impaired, e.g., as a warning device that provides a tactile sensation when a certain sound occurs nearby such as a car horn, warning sound, and the like. Furthermore, the invention could be used in conjunction with a voice analyzer to provide a hearing impaired person with a tactile sensation in response to certain spoken words.

Although various embodiments which incorporate the teachings of the present invention have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings.

What is claimed is:

1. In a virtual reality computer system, apparatus for providing, in response to signals generated by said virtual reality computer system, a tactile sensation to a user of said virtual reality computer system, said apparatus comprising:

a flexible pad;

a plurality of actuators, attached to said pad, for selectively generating said tactile sensation; and

a control circuit, coupled to said plurality of actuators, where said control circuit is responsive to an audio signal for generating a control signal to control activation of said plurality of actuators, where said audio signal corresponds to action portrayed on said virtual reality computer system.

2. The apparatus of claim 1, wherein said flexible pad further comprises:

a first portion being substantially rectangular;

a second portion, attached along an edge to said first portion, being substantially rectangular; and
where said first portion interfits with a back portion of a chair and said second portion interfits with a seat portion of a chair.

3. The apparatus of claim 1 wherein said flexible pad is affixed to a stationary seating system.

4. The apparatus of claim 1 wherein said flexible pad is substantially shaped as a motorcycle seat.

5. The apparatus of claim 1 wherein each actuator in said plurality of actuators are imbedded within said flexible pad.

6. The apparatus of claim 1 wherein each actuator in said plurality of actuators is an electric motor having a shaft with an offset weight attached thereto.

7. The apparatus of claim 6 wherein each of said electric motors are enclosed in a housing.

8. The apparatus of claim 7 wherein each of said electric motors is embedded in said flexible pad and a covering material is affixed to a surface of the flexible pad where each of said electric motors are sealed within said flexible pad by said covering material.

10

9. The apparatus of claim 1 wherein each actuator in said plurality of actuators is independently activated.

10. The apparatus of claim 1 wherein said plurality of actuators are organized into groups and each of said groups are independently activated.

11. The apparatus of claim 1 wherein each of said actuators is a solenoid.

12. The apparatus of claim 2 wherein said first portion contains a first set of actuators and said second portion contains a second set of actuators.

13. The apparatus of claim 12 wherein said first set of actuators is linearly arranged to generate a tactile sensation in the back of said user.

14. The apparatus of claim 12 wherein said second set of said actuators is arranged to generate a tactile sensation in the buttocks and legs of said user.

15. The apparatus of claim 1 wherein said control circuit comprises:

an audio signal processor for processing said audio signal and generating a processed signal; and

a control signal generator, coupled to said audio signal processor, for generating, in response to said processed signal, said control signal.

16. The apparatus of claim 15 wherein said audio signal processor generates said processed signal in response to a frequency, amplitude and rate of change of said audio signal, where said audio signal corresponds to a scene displayed on the virtual reality computer system.

17. The apparatus of claim 16 wherein said audio signal processor further comprises an equalizer for selectively amplifying or attenuating selected frequency bands of said audio signal.

18. The apparatus of claim 17 wherein said audio signal processor further comprises a rectifier for rectifying said audio signal.

19. The apparatus of claim 15 wherein said control signal generator further comprises an oscillator for generating timing signals for said control signal generator.

20. The apparatus of claim 1 wherein said control circuit comprises:

a front end circuit for forming a composite audio signal from a stereophonic audio signal;

a variable gain preamplifier, coupled to said front end circuit, for amplifying said composite audio signal;

an equalizer, coupled to said variable gain preamplifier, for selectively filtering said amplified composite audio signal;

a rectifier, coupled to said equalizer, for rectifying said equalized signal;

a peak hold circuit, coupled to said rectifier, for temporarily holding said rectified signal and for adding a DC bias to said rectified signal to generate a processed signal; and

a control signal generator, coupled to said peak hold circuit, for generating, in response to said processed signal, said control signal.

21. In a virtual reality computer system, apparatus for providing, in response to signals generated by said virtual reality computer system, a tactile sensation to a user of said virtual reality computer system, said apparatus comprising:

a stationary seating system;

a flexible seat cushion affixed to said stationary seating system;

a plurality of actuators, attached to said flexible seat cushion, for selectively generating said tactile sensation; and

5,669,818

11

a control circuit, coupled to said plurality of actuators, where said control circuit is responsive to an audio signal for generating a control signal to control activation of said plurality of actuators, where said audio signal corresponds to action portrayed on said virtual reality computer system.

22. The apparatus of claim 21, wherein said flexible seat cushion further comprises:

a first portion forming a back portion for said seating system; and

a second portion, attached along an edge to said first portion, forming a seat portion of said seating system.

23. The apparatus of claim 21 wherein said flexible seat cushion is substantially shaped as a motorcycle seat.

24. The apparatus of claim 21 wherein each actuator in said plurality of actuators are imbedded within said flexible seat cushion.

25. The apparatus of claim 21 wherein each actuator in said plurality of actuators is an electric motor having a shaft with an offset weight attached thereto.

26. The apparatus of claim 25 wherein each of said electric motors are enclosed in a housing.

27. The apparatus of claim 26 wherein each of said electric motors is embedded in said flexible seat cushion and a covering material is affixed to a surface of the flexible seat cushion where each of said electric motors are sealed within said flexible seat cushion by said covering material.

12

28. The apparatus of claim 21 wherein each actuator in said plurality of actuators is independently activated.

29. The apparatus of claim 21 wherein said plurality of actuators are organized into groups and each of said groups are independently activated.

30. The apparatus of claim 21 wherein each of said actuators is a solenoid.

31. The apparatus of claim 22 wherein said first portion contains a first set of actuators and said second portion contains a second set of actuators.

32. The apparatus of claim 31 wherein said first set of actuators is linearly arranged to generate a tactile sensation in the back of said user.

33. The apparatus of claim 31 wherein said second set of said actuators is arranged to generate a tactile sensation in the buttocks and legs of said user.

34. The apparatus of claim 22 further comprising a chest portion containing at least one actuator, said chest portion being supported by a harness that positions the chest portion against the chest of said user.

35. The apparatus of claim 34 wherein said harness is pivotable to a first position where the chest portion is maintained against the chest of said user and a second position where the chest portion is separated from the chest of said user.

* * * * *

EXHIBIT C

4/26/12

Ultimate Game Chair: The Ultimate Video Game Chair



[Home](#) | [Products](#) | [Support](#) | [Media Coverage](#) | [Testimonials](#) | [Company Info](#)

[Game Chair Support](#)[Game Chair Returns](#)[Game Chair Support FAQs](#)[Gamers' Environment](#)

Ultimate Game Chair Frequently Asked Questions - FAQ



Can I connect two or more Reactor Game Chairs together?

Yes, you can with a pair of RCA splitters available at Radio Shack and online @ the link below:

<http://www.cablestogo.com/product.asp?cat%5fid=2009&sku=03181>



Can I plug in my own controller?

With the Ultimate Game Chair, you do not plug the controller into the game chair but directly into the game console. So, you can use any controller, wireless controller and any game accessory as well.



Do we sell wholesale?

We do offer price breaks at higher quantity purchases. Ideally, we prefer wholesale purchases at full 40' container lots, shipped directly to you from our factory in China.

Please contact us at email@ultimategamechair.com for a complete quote.



Do we ship internationally?

We currently have international distribution:

UK - The Gaming Collection.

Games House

Lancashire

PR7 4NY

Tel: 01257 477060

email: info@thegamingcollection.com

Australia

Telephone: +08 9303 4652

info@thegamingcollection.com.au

<http://www.thegamingcollection.com.au/>



Do we ship to the UK?

Please check with our UK Distributor, The Gaming Collection.

Games House

Lancashire

PR7 4NY

Tel: 01257 477060

email: info@thegamingcollection.com



Do you offer volume discounts?

Yes, please email us @ email@ultimategamechair.com with your quantity requested, date required, delivery address and indicate if the address is commercial or residential. We will get back to you within 2 business days with a quote valid for 10 days.



Does it use speakers to create the vibration?

4/26/12

Ultimate Game Chair: The Ultimate Video Game Chair

No – the Ultimate Game Chair each uses GameSync™ vibration motors that are synchronized to the game action. When you pull the trigger, the chair vibrates. When the car crashes, the chair vibrates. When the quarterback is sacked, that's when the chair vibrates. This creates a more intense game experience and bottom line makes games more fun!

**How big are the Ultimate Game Chairs?**

The dimensions are as follows:

Reactor Game Chair 33" L x 17" W x 24" H 31 lbs.
 Reactor Mini Game Chair 25.75" H x 14.5" W x 24.5" H 13 lbs.
 Ultimate Game Chair V3 38" L x 43" H x 29" W 60 lbs.

**How big is the Reactor Game Chair?**

You can download our full specifications at:

http://www.ultimategamechair.com/reactor_lo.pdf

**How do I feel the game?**

The Ultimate Game Chair uses GameSync™ vibration motors that match the game action, in variable intensities. So with major explosions, you feel the motors fire in maximum intensity. With small gunfire, the motors fire at about 10%, so game play is more realistic.

**How do I get for my Ultimate Game Chair that is out of warranty?**

All replacement parts are subject to availability and all shipping charges are the responsibility of the customer. Send an email to support@ultimategamechair.com with your chair model, store purchased, and the part required. Our Technical Support will email you within 24 - 48 business hours of the availability and price of the parts.

**How does it connect to a PC?**

The Ultimate Game Chair connects to the PC using the supplied RCA cable to the PC Sound Card. Also included with the game chairs is a 3.5 mm male to male connection that allows the game chair to connect through the stereo headphone jack on a PC.

**How hard is it to set up?**

The Ultimate Game Chair is very simple to set up. The back rest slides onto the base and clicks into position. Then make the connections to our game console and you are ready to go.

**How long has this been around?**

Ultimate Game Chair was started in 2003 as a true garage invention. The Ultimate Game Chair has been in development for 2 years and began sales in March 2005.

If you do a Google search on Ultimate Game Chair, you will find all what the media has been saying about the Ultimate Game Chair – they love it!

Google Search: Ultimate Game Chair

**How long will it take to get to me?**

As soon as the product ships, it normally takes 3 – 5 business days in the US.

**I am having trouble connecting to my game console Please help**

From the game console cable that connects to the TV, there is a red, white & yellow connector. Unplug the red and white from the TV.

The game chair came with a stereo cable with red & white ends. It also came with a female to female adapter that looks like a small pair of binoculars.

4/26/12

Ultimate Game Chair: The Ultimate Video Game Chair

pair of binoculars.

Connect the stereo cable to the female adapter, then connect the female adapter to the Game Console red and white that were plugged into the TV.

If you have an older TV that uses a cable or coax connection, you will need to purchase an RF Modulator that is available at Radio Shack to get the stereo connections that are needed.



I get left side audio out of the right speaker and right side out of the left speaker How can I fix this?

Switch the RCA Stereo Cable inputs - red to white and white to red.



Is it compatible with the Nintendo Wii?

The Ultimate Game Chair is fully compatible with the Nintendo Wii. The Ultimate makes Wii games very fun as the games have tons of vibration. Racing games with the Wii are incredible. Even bowling in the Ultimate is incredible as you feel the pins crash.



Is it compatible with the PlayStation 3?

The Ultimate Game Chair is fully compatible with the PS3. The Ultimate makes PS3 games actually playable as you feel every car crash, gun shot and explosion with incredible game audio.



Is it compatible with the Xbox 360?

The Ultimate Game Chair is fully compatible with the Xbox 360. Games such as Halo 3, Gears of War, Call of Duty, Burnout Revenge are absolutely incredible in the Ultimate Game Chair.



My game console connects to my television using a cable connection How do I connect the game chair?

You will need to purchase an RF Modulator that is available at Radio Shack. This will convert your coax (cable) connection to an RCA (yellow, red, white stereo) and allow you to connect the game chair stereo cable to the RF Modulator.



PS3 Question I use HDMI for my 1080p television Will audiovideo quality be hurt?

You can still hook up the HDMI for the video and in the PS3 set up, change the audio to output using the RCA connectors. This will not effect the video quality.

In the PS3 Menu, go to Settings -> Sound Settings -> Audio Output Settings -> Select AV Multi



What comes with my order?

With the Ultimate Game Chair, we include a power supply, 6' audio cable, and 3.5mm male to male audio cable.



What games do they work with?

The Ultimate Game Chair is compatible with all games on the Xbox 360, PS3, Wii, PC, iPod & PS2.



What happened to the Renegade Game Chair?

We are currently redesigning the Renegade Game Chair, and the new release date has not been announced.



What is the difference between the Renegade Game Chair and the Reactor Game Chair?

The Reactor Game Chair features our same GameSync™ technology, so game play is just as good as it is on the Renegade Game Chair.

The Reactor does not have armrests, neckrest, does not recline, no ground effects lighting, no storage drawer and no cup holder. It is approximately the same size as the Renegade, but sits about 2 inches higher than the Renegade.



What is the shipping cost?

4/26/12

Ultimate Game Chair: The Ultimate Video Game Chair

**What is the shipping cost?**

The Reactor Game Chair costs \$60.00 by UPS Ground within the US. The Ultimate Game Chair V3 costs \$135 by UPS Ground within the US.

**What is the warranty?**

90 days parts and labor. Shipping is not included under any circumstances.
We do offer an 9 month extended warranty on the Ultimate Game Chair web site for \$59 and a 3 year extended warranty for \$259.

**What is the weight limit of the Reactor Game Chair?**

The Reactor Game Chair is warrantied at 200 lbs.

**What is this?**

This is the Ultimate Game Chair. Each game chair brings the video game experience like never before. The Ultimate Game Chairs features GameSync™ vibration motors that move with the game action, so you feel every gunshot, car crash and quarterback sack. It also feature 3D stereo sound with speakers built into the headrest so you play like never before. It's the closest virtual reality game experience on the market.

**Where can I buy an AC Adapter for the Renegade Game Chair?**

Generally available at Radio Shack or other electronics stores. The specifications are:

- * 2 - 2.5 A
- * 3.5 mm pin
- * 'Outer Sleeve' dimension 5.46mm of the plug
- center pin is + and the outer is -

**Where can I purchase replacement parts?**

The RCA Audio Cable can be purchased at this link:

http://www.ultimategamechair.com/accessory_details.php?item=243157.89473684

The AC Adapter can be purchased at this link:

http://www.ultimategamechair.com/accessory_details.php?item=267473.68421053

**Where can I try the Reactor Game Chair in Canada?**

We currently do not have any distribution in Canada for the Reactor Game Chair.

**Which game chair works best for my Game Center?**

All of the Ultimate Game Chair models work great in a Game Center environment. We highly recommend securing the cords, either under the carpet, or use a cord runner.

It is also important to monitor the use of your equipment, especially the Ultimate Game Chairs. We do not recommend allowing your customers unsupervised use of the game chairs or any of your equipment.

**Will the Reactor Game Chair work with my PC?**

Yes, the Reactor Game Chair is fully compatible (vibration and audio) with PC & Mac games.

However, the Reactor is somewhat low for desktop PC gamers and there is no tray for keyboard and mouse use.

**Is this the same game chair that was in The 40 Year Old Virgin?**

Yes, we are the same company. We have evolved the design and that original game chair is no longer in production. The producers of the movie approached the manufacturer and the Ultimate Game Chair has great coverage in the movie. The game chair was also in other movies – Grandma's Boy (2006), The Controller (2007) & Stay Alive (2006).

4/26/12

Ultimate Game Chair: The Ultimate Video Game Chair



[Home](#) | [Products](#) | [Support](#) | [Media Coverage](#) | [Testimonials](#) | [Company Info](#) | [Trademark Disclaimers](#) | [Game Chair Reviews](#)
Contact us at (925) 756-6944 to speak with a Customer Service Representative or submit a service request
©2008 UltimateGameChair.com | eCommerce Web Site Design by The PHP Kemist

International Dealers



EXHIBIT D

1/27/12

Raptor Ultimate Game Chair : Target

INTERNET ARCHIVE
WaybackMachine

http://www.target.com/Raptor-Ultimate-Game-Chair/dp/B000OKRNFQ

Go

FEB MAR MAY

31 captures

5 Nov 07 - 4 Feb 10

◀ 27 ▶

2007 2008 2009



All Products

[Sign In](#) | [New Guest?](#)

Weekly Ad: This week it's only online, with in-store deals and fabulous finds >

Browse Similar Items

[All Teen Seating](#)
[All Teen Furniture](#)
[Video Game Furniture](#)
[All Furniture](#)
[Audio Rockers](#)
[Audio Rockers](#)
[All Teen Room Furniture](#)
[Audio Rockers](#)
[Video + Audio Rockers](#)
[All Furniture + Dorm Essentials](#)
[Audio + Video Rocker](#)
[Dorm](#)
[Audio Rockers](#)
[Universal Accessories](#)
[Gaming Chairs + Accessories](#)



VIEW LARGER IMAGE

Avg. Guest Rating: ★★★★★

Availability :

Usually ships within 3 to 5 days

This item is available online, but is not available in stores.

Prices, promotions, styles and availability may vary by store and online.

FEATURES DESCRIPTION ADDITIONAL INFO SHIPPING INFO

- Improve Your Performance in First-Person Shooting Games, like Halo 3 or Call of Duty 4, with Headrest Speakers that Amplify Enemy Dialogue and Vibration Motors that Distinguish Each Weapon and Kind of Attack with a Unique Intensity
- The Perfect Accessory for Guitar Hero 3 Players, the Vibration and Audio Combine to Make Songs Come Alive, So You Don't Just Play the Song, You Feel the Music
- Experience the Ultimate in Immersive Gaming in the Hi Tech Videogame Chair
- LED Lights Illuminate Ground Surrounding Chair
- Great for Your Play Station 2, iPod, Game Cube, DVD, MP3 Player, CD Player, X-Box 360, PS3
- Polyester-Blend Upholstery

SEE MORE INFORMATION

Better Together

Buy this [Raptor Ultimate Game Chair](#) with [Audio X Rocker - Black](#) today!

Total List Price: \$399.98
Buy Together Today:
\$349.98

BUY BOTH NOW

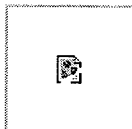
[Raptor Ultimate Game Chair](#) [Audio X Rocker - Black](#)

1/27/12

Raptor Ultimate Game Chair : Target

Our Price: **\$299.99**Our Price: **\$49.99****Guests Who Bought This Item Also Bought**Audio X Rocker - Black

temporary price cut

Our Price: **\$49.99****Related Items**Guitar Hero III: Legends of Rock Bundle for PlayStation 3Our Price: **\$99.99**Halo 3 for Xbox 360Our Price: **\$59.99**Call of Duty 4: Modern Warfare for Xbox 360Our Price: **\$59.99**Call of Duty 4: Modern Warfare for PlayStation 3Our Price: **\$59.99****Guest Reviews****Write an online review** and share your thoughts with other guests. [See all Reviews](#)**★★★★★ Wow...**, February 27, 2008Reviewer: **xXMESMERxx** (Boston, MA) - [See all my reviews](#)

If you haven't had a chance to try this chair you are missing out on an out of world experience. I play PC games most of the time but this chair in addition to my Xbox 360 and Call of Duty 4, has slowly pulled me away from PC gaming.... [read complete review](#)

Was this review helpful to you?



2 of 2 people found the following review helpful:

★★★★★ Great Addition to any gamers home, November 8, 2007Reviewer: **Jim S. Orlando FL** - [See all my reviews](#)

I consider myself a gamer and this product was a great addition to my experience. Playing games like Ace Combat when those after burners hit and your whole body is just rumbling is awesome. The only reason I didn't give it a five and I admit... [read complete review](#)

Was this review helpful to you?

**E-mail Exclusives**

Sign up to receive special offers and promotions from Target.

E-mail address:

**Gifting**Gift Finder
TargetListsClub Wedd Registry
Target Baby Registry

Gift Wrap

The REDcards

Apply Now

Manage My Account

Card Benefits

Target Business Card

Target Stores

Find a Store
Weekly Ad
SuperTarget Coupons + Specials
Target Photo
Portrait Studio
Optical
Health
Pharmacy
See All

Company Info

About Target
Our Values
Careers
Community
New s
Investors
Diversity
Affiliates
Team Member Services

Help

Track an Order
Return an Item
Contact Us
Shipping
Product Recalls
My Account
See All

1/27/12

Raptor Ultimate Game Chair : Target

[Privacy + Security](#) | [Terms + Conditions](#)
[California Privacy Rights](#) | [About This Site](#)

© 2008 Target.com. All rights reserved.
The Bullseye Design and Bullseye Dog are trademarks of Target Brands, Inc.
Powered by Amazon.com

EXHIBIT E

4/26/12

Ultimate Game Chair - Black : Target

INTERNET ARCHIVE
waybackmachine
BETA

http://www.target.com/Ultimate-Game-Chair-Black/dp/B000OKX88C

Go

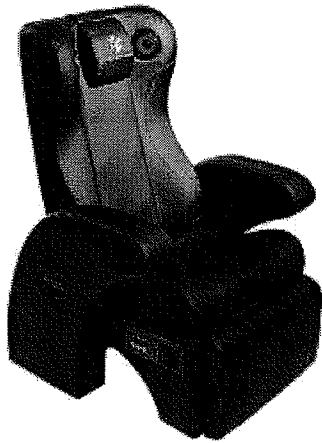
JUL OCT NOV

29 captures

16 Oct 07 - 21 Oct 10

◀ 21 ▶

2009 2010 20



(4 reviews)

\$569.99

Bullseye Free Shipping
with Qualifying \$50 Order
Save 10% When
You Spend \$100

Prices, promotions, styles and
availability may vary by store
and online.

In Stock

This item can be combined with other eligible items for Bullseye Free Shipping when you spend \$50.

Discount applied at Checkout.

[See offer details.](#)

Online only, Save 10% when you spend \$100 or more on select Home items. Discount applied at Checkout.

[See offer details.](#)

Guests who viewed this item ultimately bought:



83% bought the item featured on this page:
Ultimate Game Chair - Black 4.5 stars (4)

\$569.99

9% bought:
E1000 Gaming Chair - Gray

\$399.99

3% bought:
Boom Chair A44 Gamer - Black with Green

\$129.99

4/26/12

Ultimate Game Chair - Black : Target

Features

- **Frame Material:** Metal
- **Textile Material:** 100 % Faux Leather
- **Fill Material:** 100 % Foam
- **Finish:** Matte
- **Features:** Recline, Contoured Seat
- **Care and Cleaning:** Wipe Clean With a Damp Cloth
- **Dimensions:** Height: 44.0 " ; Width: 34.0 " ; Depth: 31.0 "

Additional Information

[Product, Sizing & Measuring Guides](#)

[Proposition 65 Information](#)

DPCI: 242-04-9466

ASIN: B000OKX88C

Catalog #: 10547976

Assembly required; tools provided.

Item can not be gift wrapped.

Made in the USA or Imported

Shipping & Policies

- [This item cannot be returned to a Target store; find out how to return this item to Target.com.](#)
- [Shipping & Delivery Information](#)
- Estimated Ship Dimensions : 32 inches length x 28 inches width x 26 inches height
- Estimated Ship Weight: 88.00 pounds.
- This item can only be shipped to the 48 contiguous states. We regret it cannot be shipped to APO/FPO, Hawaii, Alaska, or Puerto Rico.
- This item must be shipped separately from other items in your order. A separate shipping charge will also apply.
- We regret that this item cannot be shipped to PO Boxes.

Guest Reviews

Target does not endorse, recommend or sponsor any guest product reviews, ideas or advice.

Average Rating

	3
4 reviews	0
	1
	0
	0

[Write your own Review >](#)

Sort By Most Helpful First

1-4 (of 4 Reviews)

Most Helpful Review

20 out of 22 people found the following review helpful:

LUXURIOUS AND INTENSE May 10, 2007

Reviewer: **Rob_in_Orange** (Orange, CA, USA)

[See all my reviews >](#)

Having been one of the lucky ones to get my hands on the Raptor chair, I was excited to buy one of these babies for my rec room. Even though I knew the quality would exceed or match that of the Raptor, when I unwrapped the Ultimate Game Chair the first time and took it for a spin I was so happy I couldn't stop smiling. The chair's reclining action make it so comfy it is a real pain to stop playing games. I did have a question with connecting the chair to my TV and so called customer support. They were extremely quick and polite with their response so I was able to set everything up just the way I

4/26/12

Ultimate Game Chair - Black : Target

like it. Awesome chair, awesome experience and a virtual gaming experience like no other on the market today. Thank goodness someone made this chair!

Was this review helpful to you?

10 out of 10 people found the following review helpful:

THE BEST GIFT April 3, 2007

Reviewer: **GMR4LIFE "UGC"** (Ontario, Canada) [See all my reviews >](#)

My husband won't get out of it! He absolutely loves his Ultimate Game Chair. He says it was the best gift he ever received from me. We also bought a Raptor and I love that game chair for myself, although I think it's time to upgrade to the Ultimate Game Chair.

Was this review helpful to you?

9 out of 11 people found the following review helpful:

ULTIMATE GAME CHAIR IS TOTALLY AWESOME! May 8, 2007

Reviewer: **Heavy Shopper "Shop Master"** (Salt Lake City, UT) [See all my reviews >](#)

We recently saw the Raptor video game chair at the CES 2006 gamer and consumer electronics show in Las Vegas. My son and I are both heavy gamers and thought this was the coolest video game accessory on earth! We bought both the Raptor game chair and the Ultimate game chair. My son uses the Raptor and I use the Ultimate game chair and we can engage intense combat for days on end. The motors in the chair really intensify combat scenes, and with the stereo speakers you can locate enemies and action much faster. There are a bunch of buttons to control the motors and lights and there's a place to store a drink too. BEWARE: My wife confiscated my chair to listen to her iPod and use the massage features!

Was this review helpful to you?

OVER PRICED January 8, 2010

Reviewer: **hnl** [See all my reviews >](#)

Not worth the price. Not comfortable and way too small. I bought it for my son's 12th birthday and he has used it for almost one year. It is made well but very small. When it is reclined, his legs hang off at about mid calf. He put a foot stool under his feet because it is too short. It doesn't have padding on the armrest or back. If it is for a younger child I guess it would be alright, but I wouldn't buy it for anyone over 5 feet tall.

Was this review helpful to you?

Related terms: [rocking chairs](#) [audio chair](#) [video chair](#) [gaming](#) [game rocker](#)